



# Glossary

## Common 3D Stereographic Terms

**2D:** Two dimensional. An image or object with only two dimensions, such as width and height, but no depth.

**2D+Delta:** A single image along with data that represents the difference between that image view and a second eye image view along with other additional metadata. The delta data could be spatial temporal stereo disparity, temporal predictive or bidirectional motion compensation.

**2D signal processing:** A signal processing chain where 2D and 3D signals receive the same processing steps and the processor does not need to know what type of signal is being processed.

**3D:** Having or appearing to have width, height, and depth (three-dimensional). Accepts and/or produces uncompressed video signals which convey 3D.

**3D adjustment setting:** Changes the apparent depth of objects on a 3D view screen.

**3D Distribution (or transport) formats:** Transmitted to the end user over the air, over cable, over satellite, over the Internet or on packaged media. These formats typically need to be compressed on the service provider side and decompressed on the network termination at home.

**3D format:** An uncompressed video signal type used to convey 3D over an interface.

**3D in-home formats:** Connect in-home devices to the 3D display system. In-home formats may be compressed or uncompressed. The decompression and decoding/transcoding can be done in several places in the home and can include additional demodulation of RF-modulated signals as well. Video decoding and 3D decoding may be done at different locations in the signal chain, which could require two different in-home formats.

**3D native display formats:** Formats that are required to create the 3D image on the particular TV. These formats may reside only in the TV, or can be decoded/transcoded outside of the the TV. Normally, once a signal is decoded into the 3D native display format, no additional 3D signal processing is required to display the signal although there is likely to be additional 2D processing. The 3D native display format is different from the native 3D display format or resolution, which refers to the 3D pixel arrangement.

**3D signal processing:** A video signal processing chain where the processing of the signal is different for 3D video than it is for 2D video and the processor must be aware of the type of signal it is processing.

**3D DVD:** A DVD movie recorded in 3D

**3D ready:** Contains 3D decoder/transcoder and may accept and/or produce uncompressed video signals which convey 3D.

\* Note: all terms found here were all gathered from various sources including Lenny Lipton, the 3D consortium and the International Stereoscopic Union. Glossary terms can change and new terms can be added.

**3D rendering:** The process of producing an image based on three-dimensional data stored within a computer.

**3D viewing:** The act of viewing a 3D image with both eyes in order to experience stereoscopic vision and binocular depth perception.

**Accommodation:** The refocusing of the eyes as their vision shifts from one distance plane to another.

**Accommodation -vergence relationship:** The learned relationship established through early experience between the focusing of the eyes and verging of the eyes when looking at a particular object point in the visual world. Usually called the accommodation/convergence relationship (or the convergence accommodation relationship.)

**Accommodation-convergence link:** The physiological link which causes the eyes to change focus as they change convergence, a link which has to be overcome in stereo viewing since the focus remains unchanged on the plane of the constituent flat images.

**Accommodative facility:** The eyes ability to repeatedly change focus from one distance to another. Often measured by use of special flipper lenses. Measurement of each eye in turn is usually made followed by comparing the performance to that of both eyes working together.

**Active glasses:** Powered shutter glasses that function by alternately allowing each eye to see the left-eye/right-eye images in an eye sequential 3D system. Most commonly based on liquid crystal devices. \*See *passive glasses*.

**Active stereo:** \*See *eye sequential 3D*.

**Addressable hologram:** A hologram that can be changed in real time or near real time.

**AIP -Anterior Intraparietal Cortex:** An area of the human brain that is uniquely sensitive to visual cues.

**Amblyopia:** "Lazy eye". A visual defect that affects approximately 2 or 3 out of every 100 children in the United States. Amblyopia involves lowered visual acuity (clarity) and/or poor muscle control in one eye. The result is often a loss of stereoscopic vision and binocular depth perception.

**Anaglyph:** A type of stereogram (either printed, projected or viewed on a TV or computer screen) in which the two images are superimposed but are separated, so each eye sees only the desired image, by the use of colored filters and viewing spectacles (commonly red and cyan, or red and green). To the naked eye, the image looks overlapping, doubled and blurry. Traditionally, the image for the left eye is printed in red ink and the right eye image is printed in green ink.



**Angular Resolution:** The angular resolution determines the smallest angle between independently emitted light beams from a single screen point. It can be calculated by dividing the emission range with the number of independently addressable light beams emitted from a screen point. The angular resolution determines the smallest feature (voxel) the display can reconstruct in a given distance from the screen.

**Analyzers:** Devices placed in front of the eyes to separate the left and right eye images, mainly when projected. Typically, these are polarizing spectacles, anaglyph spectacles or liquid crystal shutters.

**Auto-stereoscopic:** 3D displays that do not require glasses to see the stereoscopic image. Multiview auto-stereoscopic displays based on parallax barrier or lenticules are sometimes called parallax panoramagram displays.

**Beamsplitter:** A device consisting of prisms and/or mirrors that can be attached to a mono camera to produce two side-by-side images (usually within a single frame). More accurately described as an image-splitter, as it does not split an individual beam into components. Because the groups of light rays forming the left and right images cross over as they pass through the camera lens, the recorded images end up in the correct configuration for stereo viewing without the need for the usual transposition.

**Binocular:** Of or involving both eyes at once. The term binocular stereopsis (two-eyed solid seeing) is used in some psychology books for the depth sense more simply described as stereopsis.

**Binocular depth perception:** A result of successful stereo vision; the ability to visually perceive three dimensional space; the ability to visually judge relative distances between objects; a visual skill that aids accurate movement in three-dimensional space.

**Binocular disparity:** The difference between the view from the left and right eyes.

**Binocular vision:** Vision as a result of both eyes working as a team; when both eyes work together smoothly, accurately, equally and simultaneously.

**Binocular vision disability:** A visual defect in which the two eyes fail to work together as a coordinated team resulting in a partial or total loss of binocular depth perception and stereoscopic vision. At least 12% of the population has some type of binocular vision disability. Amblyopia and strabismus are the most commonly known types of binocular vision disabilities.

**Breaking the frame:** If an object has Negative Parallax and is bisected by the edge of the frame then that object is 'breaking the frame' and there is a visual/brain conflict.

**Broadband light:** Light with a range of optical wavelengths that is comparable to the bandwidths associated with the red, green and blue light of a display.

**Card boarding:** A condition where objects appear as if cut out of cardboard and lack individual solidity. Usually the result of inadequate depth resolution arising from, for example, a mismatch between the focal length of the taking lens, the stereo base and/or the focal length of the viewing system.

**Chromatic stereoscopy:** An impression of depth which results from viewing a spectrum of colored images through a light-bending device

such as a prism, a pinhole or an embossed 'holographic' filter, caused by variations in the amount of bending according to the wavelength of the light from differing colors (chromatic dispersion). If such a device is placed in front of each eye, but arranged to shift planar images or displays of differing colors laterally in opposite directions, a 3D effect will be seen. The effect may also be achieved by the lenses of the viewer's eyes themselves when viewing a planar image with strong and differing colors. Typically, with unaided vision, red portions of the image appear closer to the viewer than the blue portions of the image. Sometimes called Chromostereopsis.

**Circular polarization:** A form of polarized light in which the tip of the electric vector of the light ray moves through a corkscrew in space.

**Column interleaved format:** A 3D image format where left and right view image data are encoded on alternate columns of the display.

**Compressed video signal:** A stream of compacted data representing an uncompressed video signal. A compressed video signal is an encoded version of an uncompressed video signal. A compressed video signal must be decoded to an uncompressed video signal in order to be edited or displayed. Compressed video formats vary according to the encoding methods used. A compressed video signal format may be converted to another using a 'transcoder'.

**Convergence:** The ability of both eyes to turn inwards together. This enables both eyes to be looking at the exact same point in space. This skill is essential to being able to pay adequate attention at near to be able to read. Not only is convergence essential to maintaining attention and single vision, it is vital to be able to maintain convergence comfortably for long periods of time. For good binocular skills it is also to be able to look further away. This is called divergence. Sustained ability to make rapid convergence and divergence movements are vital skills for learning.

The term has also been used, confusingly, to describe the movement of left and right image fields or the rotation (toe-in) of camera heads.

**Corresponding points:** The image points of the left and right fields referring to the same point on the object. The distance between the corresponding points on the projection screen is defined as parallax. Also known as conjugate or homologous points.

**Crosstalk:** Incomplete isolation of the left and right image channels so that one leaks (leakage) or bleeds into the other. Looks like a double exposure. Crosstalk is a physical entity and can be objectively measured, whereas ghosting is a subjective term. See ghosting

**CRT:** Cathode ray tube. Direct view CRTs have often been used in eye-sequential 3D systems. The decline of the CRT has led to a search for alternative cost effective 3D display systems.

**Depth budget:** The combined values of the Positive and Negative Parallax. Often given as a % of screen width.

**Depth perception:** The ability to see in 3D or depth to allow us to judge the relative distances of objects. Often referred to as stereo vision or stereopsis.

**Depth range:** A term that applies to stereoscopic images created with cameras. The limits are defined as the range of distances in camera space from the background point producing maximum acceptable positive parallax to the foreground point producing maximum acceptable negative parallax.



**Diplopia:** 'Double vision'. In stereo viewing, a condition where the left and right homologues in a stereogram remain separate instead of being fused into a single image.

**Direct view:** A display where the viewer looks directly at the display, not at a projected or virtual image produced by the display. CRTs, LCDs, Plasma panels and OLEDs can all be used in direct view 3D displays

**Discrete views:** The 3D view from any position is provided by a single image source (see distributed views too).

**Disparate images:** A pair of images that fail as a stereogram (e.g., due to distortion, poor trimming, masking, mismatched camera lenses, or the like).

**Disparity:** The distance between conjugate points on overlaid retinas, sometimes called retinal disparity. The corresponding term for the display screen is parallax.

**Disparity Difference:** The parallax between two images representing the same scene but acquired from two different viewing angles. The disparity between homologous points is used to compute the elevation.

**Display:** An electronic device that presents information in visual form, that is, produces an electronic image- such as CRTs, LCDs, plasma displays, electroluminescent displays, field emission displays, etc. Also known as a 'sink' that renders an image.

**Display surface:** The physical surface of the display which exhibits information (synonym: screen).

**Distortion:** In general usage, any change in the shape of an image that causes it to differ in appearance from the ideal or perfect form. In stereo, usually applied to an exaggeration or reduction of the front-to-back dimension.

**Distributed views:** The 3D view at any one time and position from multiple image sources. Also see discrete views.

**Divergence:** The ability for the eyes to turn outwards together to enable them to both look further away. The opposite of convergence. It is essential for efficient learning and general visual performance to have good divergence and convergence skills.

**DLP:** Digital light processing. *Also see MEMs.*

**Dwarfism:** *See Lilliputism.*

**Emissive:** A self-luminous display where there is no separate lamp. CRTs, Plasma panels, LEDs and OLEDs are examples.

**Extra-stereoscopic cues:** Those depth cues appreciated by a person using only one eye. Also called monocular cues. They include interposition, geometric perspective, motion parallax, aerial perspective, relative size, shading, and textural gradient.

**Eye-dedicated displays:** A 3D display system where there are two separate displays to produce the left and right eye images and the geometry of the system is arranged so each eye can only see one displays.

**Eye sequential 3D:** The images in a stereo pair are presented alternately to the left and right eyes fast enough to be merged into a single 3D image. At no instant in time are both images present. The images may be

separated at the eyes by active or passive glasses.

**Eye tracking:** *See Tracking.*

**Eyewear:** Anything worn on the head and eyes to produce a 3D image. This includes both passive and active glasses or head mounted displays. Consumer-grade 2D and 3D HMDs are often specifically called eyewear. Passive and active glasses are often just called glasses.

**Far point:** The feature in a stereo image that appears to be farthest from the viewer.

**Field of Depth:** The field of depth determines the largest depth a display can visualize with a defined minimum resolution. For displays with fixed emission range and angular resolution, the size of the smallest displayed feature depends on the the distance from the screen. The smallest feature (voxel) the display can reconstruct is the function of the distance from the screen and the angular resolution. If we set an upper limit on the feature size, the angular resolution determines the distance from the screen, within which the displayed features are smaller than the given limit. This range is the Field of Depth, which effectively determines the largest displayable depth below which the features are within given limit.

**Field of view:** Usually measured in degrees, this is the angle that a lens can accept light. For instance, the human eye's horizontal field of view is about 175°.

**Field sequential:** The rapid alternation of left and right views in the video format, on the display or at the eye.

**Fields per second:** The number of sub-images presented each second. the sub-image can be defined by the interlace pattern, the color or the left/right images in a stereo pair.

**Film:** A sheet of material that is thin compared to its lateral dimensions. Films are used to modify the light passing through or reflecting off of them. Films can modify the brightness, color, polarization or direction of light. Film encoded with images can be used in projection systems as an image source.

**Floating image:** A display where the image appears to be floating in mid-air, separated from any physical display screen.

**Fore window image:** An image that appears in front of the stereo window frame; ie, "coming through the window". Where an image cuts the edge of the window-frame, the effect is usually referred to as floating edges.

**Format:** The method used to combine images for printing, storage or transmission.

**FPD:** Flat panel display. The two most common FPDs used in 3D systems are LCDs and plasma panels. OLED FPDs are also commercially available.

**Frame compatible 3D format:** Left/Right frames organized to fit in a single legacy frame such as 480 x 720, 720 x 1280 or 1080 x 1920 pixels. The pair of images can be pixel decimated using spatial compression, color encoded like anaglyph, time sequenced like page flipping, etc.

**Frames per second:** The number of complete images delivered to the eye each second.



**Front projection:** XXXXXXX

**Frustum effect:** Front-to-back keystone distortion in the space-image so that a cube parallel to the lens-base is portrayed as the frustum of a regular four-sided truncated pyramid with the smaller face towards the observer. In reverse frustum distortion, the larger face is forward.

**Full frame stereo format:** A stereo format that uses stereo pairs of 8 perforations (film sprockets) per image width. This would be the same as a conventional camera and is used on twin camera stereo photographs and with certain RBT cameras. The Fed Camera can be modified to full frame.

**Fusion:** The merging (by the action of the brain) of the two separate views of a stereo pair into a single three-dimensional (or Cyclopean) image.

**Fusion, irregular:** Fusion of points that are not homologous, as with accidental and false stereo effects and multiple diplopia.

**Fusional reserves:** A series of measures to probe how much stress the convergence and divergence mechanisms are able to cope with when placed under stress. This is linked to the ability to maintain good clear comfortable single vision whilst keeping control of the focusing mechanism. Analysis of the results of this test are complicated. If results are low it can be expected that difficulty in concentrating for long periods will be experienced. Often headaches can result in prolonged periods of close work. Children in particular, but also adults, often show a tendency to avoid prolonged close work when the fusional reserves are low.

**Ghosting:** The perception of crosstalk is called ghosting. A condition that occurs when the right eye sees a portion of the left image or vice versa causing a faint double image to appear on the screen.

**Giantism:** Jargon term for the impression of enlarged size of objects in a stereo image due to the use of a stereo base separation less than normal for the focal length of the taking lens(es). See also hypostereo.

**Graphics Processing Unit:** A high-performance 3D processor that integrates the entire 3D pipeline (transformation, lighting, setup, and rendering). A GPU offloads all 3D calculations from the CPU, freeing the CPU for other functions such as physics and artificial intelligence.

**Height error:** xxxxxx

**Vertical error:** A fault present in a stereogram when the two film chips or prints are not aligned vertically in mounting, so that homologous points are at different heights.

**HMD:** Head Mounted Display

**Headset:** A display device worn on the user's head. Typically using LCD technology. These devices can be used in conjunction with a tracking device to create an immersive virtual reality.

**Holmes format:** A format for stereo cards that are based on a stereoscope invented by Oliver Wendall Holmes. This is the format for most antique cards and have image centers that are further apart than the human eye (3-1/2" x 7"). This is significant because any viewing device for such cards needs to have a mechanism for bending light before it reaches the eyes. Most viewers are prismatic. Later formats for cards were not as large

**Holmes stereoscope:** Usual name for the common type of hand-held stereoscope with an open skeletal frame. Named after its inventor in 1859,

the American physician and author, Oliver Wendell Holmes. Where, as is normally the case, the stereoscope includes a hood to shade the eyes and an adjustable card holder, it is more correctly termed a Holmes-Bates (or just Bates) stereoscope (after Joseph Bates who introduced these refinements).

**Holography:** "Whole drawing". A technique for producing an image (hologram) that conveys a sense of depth, but is not a stereogram in the usual sense of providing fixed binocular parallax information. Invented in theory by Dr. Dennis Gabor at Imperial College of London in 1948, holograms were not practical until the ruby laser was invented in 1960 by T.A. Mainman of Hughes Aircraft. Today, holograms are made with lasers and produce images that one can practically touch. Some appear to float in space in front of the frame, and they change perspective as you walk left and right. Holograms are monochromatic, and no special viewers or glasses are necessary, although proper lighting is important. To make a hologram, lengthy exposures are required with illumination by laser beams that must be carefully set up to travel a path with precisely positioned mirrors, beam splitters, lenses, and special film.

**Homologous points:** Identical features in the left and right image points of a stereo pair. The spacing between any two homologous points in a view is referred to as the separation of the two images (which varies according to the apparent distance of the points) and this can be used in determining the correct positioning of the images when mounting as a stereo pair.

**Horizontal image translation:** The horizontal shifting of the two image fields to change the value of the parallax of corresponding points. The term convergence has been confusingly used to denote this concept.

**Head Up Display (HUD):** A display device that provides an image floating in mid-air in front of the user.

**Hyperfocal distance:** The distance setting on the focusing scale of a lens mount which will produce a sharply focused image from infinity to half the distance of the focus setting at any specific lens aperture. Of particular value in stereo photography to ensure maximum 'depth of field', so that viewing is not confused by out-of-focus subject matter.

**Hyperstereo:** Use of a longer than normal stereo base in order to achieve the effect of enhanced stereo depth and reduced scale of a scene; it produces an effect known as Lilliputism because of the miniaturization of the subject matter which appears as a result. Often used in order to reveal depth discrimination in architectural and geological features. The converse of hypostereo.

**Hypostereo:** Using a baseline that is less than the distance between the left and right eyes when taking the pictures. This exaggerates the size of the objects, making them look larger than life. It produces an effect known as Giantism. The converse of hyperstereo. A good use for this would be 3D photographs of small objects, one could make a train set look life size.

**Image splitter:** A device mounted on the front of a single lens that, through the use of mirrors or prisms, divides the image captured on film into two halves, which are the two images of a stereoscopic pair. Sometimes called a frame-splitter, and often imprecisely called a beamsplitter

**Immersive:** A term used to describe a system that is designed to envelop the participant in a virtual world or experience. The amount of immersion the participant feels depends on a number of factors. Visual immersion is the most common goal. This can be done effectively using a large screen



or a head-mounted display.

**Infinity, stereo:** See *stereo infinity*.

**Interaxial distance:** XXXXX

**Interaxial separation:** The distance between camera lenses' axes.

**Interlaced:** A type of video stream made up of odd and even lines (or sometimes columns). Normal TV signals (like PAL and NTSC) are interlaced signals, made up of two odd and even line images called fields. These odd and even fields can be used to store stereoscopic left and right images, a technique used on 3D DVDs, although this halves the vertical resolution of the video.

**Inter lens separation:** The distance between the optical centers of the two lenses of a stereo camera or stereoscope, or (in wide-base stereography) between two photographic or viewing positions. Similar to base, stereo.

**Interocular adjustment:** A provision in some stereo viewers that allows for adjustment of the distance between the lenses of the viewer to correspond with the image's infinity separation and in some cases the distance between a viewers eyes.

**Interocular distance:** The separation between the optical centers of a twin-lens stereo viewer (which may be adjustable). Not necessarily the same as the interpupillary distance of the eyes.

**Interpupillary distance:** xxxxxx

**Interpupillary separation:** xxxxx

**Interocular separation:** The distance between the centers of the pupils of the eyes when vision is at infinity. IPDs can range from 55 to 75 millimeters in adults, but the average is usually taken to be around 65 mm, the distance used for most resolving calculations and viewer designs.

**Inversion:** The visual effect achieved when the planes of depth in a stereograph are seen in reverse order; e.g., when the left-hand image is seen by the right eye, and vice-versa. Often referred to as pseudostereo.

**IR transmitter:** A device that sends synchronization signals to wireless shutter glasses.

**JPEG:** Joint Photographic Experts Group. An image format that drastically reduces image size, at the expense of throwing out information. Most of the time, the loss of information is not noticeable. When saving an image, you can set the degree of compression you would like, at the expense of image quality. Usually, you can achieve 3:1 compression without noticing much. JPEG uses an 8x8 grid and does a discrete cosine transformation on the image. The result when compression is high and quality is low is a tiling patten and visible artifacts at high-contrast boundaries, particularly noticeable in skies.

**JPEG2000:** A newer, more computationally intensive JPEG standard. It allows for much higher compression rates than JPEG for comparable image quality loss. To achieve this, it uses a wavelet transformation on the image, which takes much more computing power, but as time progresses and machines become faster, this is less of a problem than when the first JPEG standard came out. The size of the compressible area can vary, so no tiling pattern is evident.

**JPS:** Stereoscopic JPEG file. A stereoscopic image file format that is based on JPEG compression.

**Keystoning:** Term used to describe the result arising when the film plane in a camera or projector is not parallel to the view or screen. The perspective distortion that follows from this produces an outline of, or border to, the picture which is trapezoidal in shape, resembling the keystone of a masonry arch. In stereo, the term is applied to the taking or projecting of two images where the cameras or projectors are 'toed-in' so that the principal objects coincide when viewed. The proportions of the scene will then have slight differences that produce some mismatching of the outlines or borders of the two images. Gross departures from orthostereoscopic practice (eg, if using telephoto lenses) can produce keystoning in depth; more properly called a frustum effect.

**Lenticular:** Pertaining to a lens. As used by Brewster to describe his lensed stereoscope. Shaped like a lens. In stereo, used to describe:

(1) A method of producing a depth effect without the use of viewing equipment, using an overlay of semi-cylindrical (or part-cylindrical) lens-type material which exactly matches alternating left and right images on a specially-produced print, thereby enabling each eye to see only one image from any viewing position, as in an autostereogram.

(2) A projection screen with a surface made up of tiny silvered convex surfaces which spread the reflected polarized light to increase the viewing angle.

**Lenticular screen:** A projection screen that has embossed vertical lines for its finish rather than the "emery board" finish most common. They tend to cost more. The silvered version is critical to 3D projection, as any white screen will not preserve the polarization of the image reflected off it.

**Lilliputism:** Jargon term for the miniature model appearance resulting from using a wider-than-normal stereo base in hyperstereography.

**Linear polarization:** A form of polarized light in which the tip of the electric vector of the light ray remains confined to a plane.

**Lorgnette:** A handheld pair of lenses that helps people view stereographs.

**Macro stereo:** Ultra close-up images, photographed with a much-reduced stereo base in order to maintain correct stereo recession.

**Macro stereo photography:** Stereo photography in which the image on the film is about the same size or larger than the true size of the image.

**Magic Eye:** Paintings and computer generated optical illusions that, if one can freeview, reveal hidden images of shapes and objects.

**Mirror stereoscope:** A stereo viewer incorporating angled mirrors, as in the Wheatstone and Cazes stereoscopes.

**Misalignment:** In stereo usage, a condition where one homologue or view is higher or lower than the other. Where the misalignment is rotational in both views, there is tilt; in one view only, twist. Viewing a misaligned stereogram can result in diplopia or produce eyestrain.



**Monocular areas:** Parts of the scene in a stereo image that appear in one view and not in the other. These can be natural (if behind the stereo window) or unnatural, as in the case of floating edges (if in front of the stereo window).

**Monocular cues:** See *Extra-stereoscopic Cues*.

**Mount:** In stereo usage, a special holder or card used to secure, locate and protect the two images of a stereo pair. Usually, the term includes any framing device or mask that may be incorporated.

**Mounting:** The process of fixing the left and right views to a mask or mount (single or double) so that they are in correct register, both vertically (to avoid misalignment) and horizontally (so that the stereo view is held in correct relationship to the stereo window).

**Mounting jig:** A device used to assist in the process of mounting stereo pairs in correct register, usually incorporating an alignment grid placed below the mount holder and a pair of viewing lenses above the film chips to enable each eye to focus on the appropriate image and fuse the pairs.

**MPEG:** Standards developed by Moving Picture Experts Group. A type of audio/video file found on the Internet. There are three major MPEG standards: MPEG-1, MPEG-2, and MPEG-4.

**Multiplex:** The process of taking a right and left image and combining them with a multiplexing software tool or with a multiplexer to make one stereo 3D image.

**Multiplexing:** The technique for placing the two images required for a stereoscopic display within an existing bandwidth.

**Near point:** The feature in a stereo image that appears to be nearest to the viewer.

**Near point of accommodation:** The closest distance from the eyes that reading material can be read. This distance varies with age. It is often measured in each eye separately and both eyes together. The results are compared to one and other.

**Near point stress:** The term used when close work is causing the individual unacceptable stress. This is often seen when the relationship between accommodation and convergence is maintained only by excessive effort. The response to this is either a tendency to avoid close work (known as evasion) or alternatively, to use progressively more and more effort. This is typified by a tendency to get closer and closer to the work and then to suffer slower work rates, head aches and eye discomfort. Writing often becomes labored and difficult, showing a tight pencil grip and excessive pressure. They may complain of blurred vision, print getting smaller, colored fringes around text that sometimes moves on the page and possibly double vision. There is often a generalized ocular discomfort and there can be complaints of feeling 'washed out' after prolonged concentration. Symptoms can vary from day to day.

**Nimslo:** The brand name, taken from the surnames of inventors Jerry Nims and Allen Lo, for a camera system intended primarily to produce lenticular autostereo prints, incorporating four lenses to record the same number of images (each of 4-perforations width) on 35mm film. The name is often used to identify the size of mask or mount developed to hold 4-perforation-wide pairs of transparencies made with this camera and its derivatives.

**Nimslo format:** A stereo format that uses stereo pairs of 4.5 perforations (film sprockets) per image width. This would be the equivalent of a half frame and is used with Nishika and Nimslo stereo cameras. Some cameras with beamsplitters use a 4 perforation format but this would not be called a Nimslo format.

**NTSC:** A type of interlaced video stream used primarily in North America. It is made up from 525 horizontal lines playing at 30 frames per second (or 60 fields per second).

**One-in-thirty rule:** A rule-of-thumb calculation for determining the stereo base when using a non-standard camera lens separation, eg in hyper- or macro- stereography. To achieve optimum stereo depth, the separation of the centers of the camera lenses should be around one-thirtieth of the distance from the lenses to the closest subject matter in a scene. This 'rule' only holds good under certain optical conditions (eg where 'standard' focal-length lenses are used), and usually needs to be varied when, for example, lenses of longer or shorter than normal focal length are used.

**OpenGL:** A graphics API that was originally developed by Silicon Graphics, Inc. for use on professional graphics workstations. OpenGL subsequently grew to be the standard API for CAD and scientific applications and today is popular for consumer applications such as PC games as well.

**Ortho stereo:** The ideal position and distance for viewing a stereo image.

**Orthoscopic image:** A stereoscopic image viewed with its planes of depth in proper sequence, as opposed to an inverse (or pseudo) stereoscopic image.

**Orthostereoscopic image:** An image that appears to be correctly spaced as in the original view.

**Ortho-stereoscopic Viewing:** When the focal length of your viewer's lenses is equal to that of the focal length of the taking lenses of the camera in which the slides were viewed. This is said to allow you to see the objects as being exactly the same size and with the same distance between each other in the viewer as in reality.

**Over/under format:** Over/Under format involves using a mirror system to separate the left and right images that are placed one above one another. Special mirrored viewers are made for over/under format.

**Over-and-under:** A form of stereo recording (on cine film) or viewing (of prints) in which the left and right images are positioned one above the other rather than side-by-side, and viewed with the aid of prisms or mirrors which deflect the light path to each eye accordingly.

**PAL:** A type of interlaced video stream used in the UK and around the world. It is made up from 625 horizontal lines playing at 25 frames per second (or 50 fields per second).

**Panorama pictures:** Pictures taken of the world around you as if you were turning around in a circle.

**Panum phenomenon:** A trick of stereo viewing whereby, if a single vertical line is presented to one eye and two vertical lines to the other, and one of the double lines is fused with the single line in binocular viewing, the unmatched line is perceived to be nearer or further away than the fused line. A concept used in the design of stereo mounting grids. A phenomenon first described by the scientist Panum in 1858.



**Parallax:** Apparent change in the position of an object when viewed from different points. The distance between conjugate points. Generally, the differences in a scene when viewed from different points (as, photographically, between the viewfinder and the taking lens of a camera). In stereo, often used to describe the small relative displacements between homologues, more correctly termed deviation.

**Parallax budget:** The range of parallax values, from maximum negative to maximum positive, that is within an acceptable range for comfortable viewing.

**Parallax stereogram:** A form of autostereogram which currently describes a technique in which alternate thin vertical strips of the left and right hand views are printed in a composite form and then overlaid with a grating (originally), or (nowadays) a lenticular sheet of cylindrical lenses which presents each view to the correct eye for viewing stereoscopically.

**Parallel viewing method:** Viewing a stereo image where the left view of a stereo image is placed on the left and the right view is placed on the right. This is the way most stereocards are made as opposed to cross-eyed viewing.

**Parallel free-vision fusion Parallel-viewing (The parallel method):** A free viewing technique in which the lines of sight of the two eyes aim and meet at a point beyond and behind the 3D image; the eyes move outward (away from the nose) toward PARALLEL lines of sight. It works with small images, but is somewhat limiting on a computer screen.

**Passive polarized 3D glasses:** 3D glasses made with polarizing filters. Used in conjunction with a view screen that preserves polarized light.

**Passive stereo:** A technique whereby 3D stereoscopic imagery is achieved by polarizing the left and right images differently at source, viewed using low-cost polarizing glasses.

**Photo bubble:** xxxxxxxx

**Photo sphere:** xxxxx

**Photo cube:** A form of panorama picture made of photos usually taken with a fisheye lens. They are then stitched together to produce a photo sphere or cube. The viewer can see all around, above, and below.

**Photogrammetry:** A professional discipline which uses stereography as a basis for scientific measurement and map-making. The art, science, and technology of obtaining reliable information about physical objects and the environment through processes of recording, measuring, and interpreting photographic images and patterns of recorded radiant electromagnetic energy and other phenomena.

**Planar image (Flat two dimensional):** A planar image is one contained in a two-dimensional space, but not necessarily one that appears flat. It may have all the depth cues except stereopsis.

**Plano-stereoscopic:** A stereoscopic projected image that is made up of two planar images.

**Polarization of light:** The division of beams of light into separate planes or vectors by means of polarizing filters (first practically applied by Edwin Land of the Polaroid company in the 1930s). When two vectors are crossed at right angles, vision or light rays are obscured.

**Progression (in film transport):** The amount or method by which film is advanced between exposures in a purpose-built stereo camera. The Colardeau progression moves by an even two frames; the Verascope progression moves by one and three frames alternately.

**Pseudo stereo:** The effect produced when the left view image and the right view image are reversed. This condition causes a conflict between depth and perspective image.

**Pseudoscopic:** xxxxx

**Pseudo:** The presentation of three-dimensional images in inverse order, so that the farthest object is seen as closest and vice-versa: more correctly referred to as inversion. Achieved (either accidentally or deliberately, for effect) when the left and right images are transposed for viewing.

**Pseudoscopy:** Viewing of stereo pair with images the depth or relief of an object is reversed.

**Pulfrich effect:** Term now used to describe an illusory stereoscopic effect which is produced when two-dimensional images moving laterally on a single plane (as on a film or television screen) are viewed at slightly different time intervals by each eye, the perceived delay between the eyes being achieved by means of reduced vision in one of them; eg, through the use of a neutral-density filter. The apparent positional displacement that results from this is interpreted by the brain as a change in the distance of the fused image. A scene is produced giving a depth effect, the depth being proportionate to the rate of movement of the object, not to the object distance. The phenomenon was first adequately described in 1922 by Carl Pulfrich, a physicist employed by Carl Zeiss, Jena, in relation to a moving object (a laterally-swinging pendulum).

**Pulfrich stereo:** Stereo video taken by rolling a camera sideways at a right angle to an object. When played back, the viewer wears glasses with one eye unobstructed, and the other through a darker lens. The brain is fooled into processing frames of the video in sequence, and the result is a moving stereo image in color.

**Ramsdell rig:** See *beamsplitter*.

**Random dot stereogram:** A type of stereogram in which a three-dimensional image is formed by the fusing of apparently randomly-placed dots in a stereo pair: an effect first created manually by Herbert Mobbs of The Stereoscopic Society in the 1920s but scientifically developed, using computer-generated images, by Bela Julesz in the 1960s. The random dot stereogram is a computer-generated image that could be perceived only with binocular (two-eyed) depth perception. This is a method in which a pattern is repeated at about the distance between your eyes (2.5-2.75 inches). Minor variations in the patterns from column to column will combine to give you depth information when your eyes have diverged from their focus point (relaxed focus- walleyed). This method has limitations due to the fact that only graphics-type images can be shown- not a true-color image.

**Realist Format:** The 5-perforation 35 mm slide format of 23 x 24 mm, originally created by the specification of the Stereo Realist (USA) camera, and subsequently adopted by many other manufacturers. A stereo format that uses stereo pairs of 5 perforations (film sprockets) per image width. This is the most common stereo format and is named after the camera made by the David White Company. It is used with the Kodak, TDC Colorist I and II, TDC Vivid, Revere, Wollensak, Realist, along with many other cameras too numerous to mention.



**Realtime 3D graphics:** Realtime graphics are produced on-the-fly, by a 3D graphics card. Realtime is essential if the user needs to interact with the images as in virtual reality, as opposed to watching a movie sequence.

**Rear projection:** Rear projection is when images are projected from behind a screen. The advantage of this configuration is that a viewer cannot cast shadows by getting in between the projector and screen - particularly important when a user is interacting with images on the screen. Certain types of rigid and flexible rear projection screens can be used for stereoscopic projection.

**Retinal disparity:** See *Disparity*.

**Retinal rivalry:** Retinal rivalry is the simultaneous transmission of incompatible images from each eye.

**Rig:** Dual camera heads in a properly engineered mounting used to shoot stereo movies.

**Rochwite Mount, R-mount, Rochwite:** This is the name sometimes used to delineate the 41 x 101mm, 1-5/8" x 4" (outer dimensions) mount used for almost all stereo slides. Mounts of these outer dimensions are made for the Realist, European, Nimslo, and full frame formats. Named after Seaton Rochwite, the inventor of the Realist Stereo Camera.

**Rotation:** Tilting of the images through not holding the camera horizontally, causing one lens to be higher than the other at the picture-taking stage. If the tilting is not too severe, it may be possible to straighten both images when mounting but there will be a height error, however small, in part of the image. A difference in the alignment of the two images in a stereogram caused by faulty mounting.

**Row interleaved:** A format to create 3D video or images in which each row or line of video alternates between the left eye and the right eye (from top to bottom).

**Savoy format:** A stereo format produced by prisms or other forms of image-splitter on a planar camera, side-by-side for still images and over-and-under for cine images.

**Screen space:** The region appearing to be within a screen or behind the surface of the screen. Images with positive parallax will appear to be in screen space. The boundary between screen and theater space is the plane of the screen and has zero parallax.

**Selection device:** The hardware used to present the appropriate image to the appropriate eye and to block the unwanted image. For 3D movie the selection device is usually eyewear used in conjunction with a device at the projector, like a polarizing device.

**Separation (interaxial):** The distance between two taking positions in a stereo photograph. Sometimes used to denote the distance between two homologues.

**Septum:** The partition used in a stereo camera to separate the two image paths. Any partition or design element that effectively separates the lines of sight of the eyes such that only their respective left and right images are seen by each one.

**Sequential stereograph:** A stereo pair of images made with one camera that is moved by an appropriate separation between the making of the LH and the RH exposures.

**Shutter glasses:** A device worn on your head, with two lenses generally covered in a liquid crystal material and controlled by your computer. When viewing a 3D image using these glasses, your computer displays the left image first, while instructing your glasses to open the left eye's "shutter" (making the liquid crystal transparent) and to close the right eye's "shutter" (making the liquid crystal opaque). Then in a short interval - 1/30 or 1/60 of a second, the right image is displayed, and the glasses are instructed to reverse the shutters. This keeps up for as long as you view the image. Since the time interval is so short, your brain can't tell the difference in time, and views them simultaneously. Does not require polarized light preserving screen.

**Siamese:** Used as a verb, to assemble a stereo camera from the relevant parts of two similar planar cameras. Therefore, siamesed (adjective) to describe the finished assembly.

**Silvered screen:** A type of screen surface used for passive stereoscopic front projection. These screens maintain the polarization of the light introduced by polarizing filters in front of the two projector lenses.

**Single image random dot stereogram:** A computer-generated stereogram in which the depth information is combined into a single image (a stereo pair is no longer visible to the naked eye). A form of random dot stereogram in which the stereo pair is encoded into a single composite image that each eye has to decipher separately. Popularized in the "Magic Eye" type books of the 1990s. The first single image random dot stereogram was programmed on an Apple II computer in 1979 by Maureen Clarke and Christopher Tyler.

**Slide bar:** A device for taking sequential stereo pairs of non-moving subjects, enabling a planar camera to move by an appropriate separation whilst holding the camera in correct horizontal register with the optical axes either parallel or "toed-in" to create a convenient stereo window. It is more accurate than Cha-Cha and can be used to produce 2x2 stereo format slides.

**Spinography:** This is done by walking around an object and taking pictures every 10-20 degrees, or putting the camera on a tripod and an object on a turntable and rotating it 10-20 degrees between shots. It can also be done with 3D modeling software by a computer. It does not create the same sense of depth as stereographics. To view spinography on a computer you usually need a small program for your browser called a plug-in.

**Squeeze:** Diminution of depth in a stereogram in relation to the other two dimensions, usually resulting from a viewing distance closer than the optimum (especially in projection). The opposite effect to stretch.

**Stereo:** Having depth, or three-dimensional: used as a prefix to describe, or as a contraction to refer to, various stereographic or stereoscopic artifacts or phenomena. Stereo comes from the Greek stereos for hard, firm or solid and it means combining form, solid, three-dimensional. Two inputs combine to create one unified perception of three-dimensional space.

**Stereo acuity:** The ability to distinguish different planes of depth, measured by the smallest angular differences of parallax that can be resolved binocularly.

**Stereo blind:** A term describing people who cannot fuse two images into one with depth (stereopsis).

**Stereo infinity:** The farthest distance at which spatial depth effects

are normally discernible, usually regarded as 200 meters for practical purposes.

**Stereo pair:** In 1838 Charles Wheatstone invented the first stereoscopic viewer for the 3D viewing of stereo pairs.

**Stereo vision:** xxxxx

**Stereoscopic vision Stereopsis:** Two eye views combine in the brain to create the visual perception of one three-dimensional image. A byproduct of good binocular vision. Vision wherein the separate images from two eyes are successfully combined into one three-dimensional image in the brain.

**Stereo window:** The viewing frame or border of a stereo pair, defining a spatial plane through which the three-dimensional image can be seen beyond (or, for a special effect, "coming through"). A design feature in some stereo cameras whereby the axes of the lenses are offset slightly inwards from the axes of the film apertures, so as to create a self-determining window in the resulting images which is usually set at around an apparent 2 meters distance from the viewer. If the objects appear to be closer to the viewer than this plane it is called breaking the window.

**Stereocomparator:** A stereoscopic instrument for measuring parallax; usually includes a means of measuring photograph coordinates of image points.

**Stereogram:** A general term for any arrangement of LH and RH views which produces a three-dimensional result, which may consist of:

- (1) A side-by-side or over-and-under pair of images
- (2) Superimposed images projected onto a screen
- (3) A color-coded composite (anaglyph)
- (4) Lenticular images
- (5) A vectograph
- (6) In film or video, alternate projected LH and RH images which fuse by means of the persistence of vision.

**Stereograph:** The original term, coined by Wheatstone, for a three-dimensional image produced by drawing; now denoting any image viewed from a stereogram. In more general but erroneous usage as the equivalent of stereogram.

**Stereographer:** A person who makes stereo pictures.

**Stereographoscope:** An early type of stereoscope that also carries a large monocular lens (above the two regular stereoscopic lenses) for the viewing of planar photographs.

**Stereographs:** xxxxxx

**Stereograms:** xxxxxx

**Stereopairs:** Two images made from different points of view that are side by side. When viewed with a special viewer the effect is remarkably similar to seeing the objects in reality.

**Stereography:** The art and practice of three-dimensional image making.

**Stereojet prints:** Made of a special transparency material with polarized

images inkjetted onto each side, they can be displayed as transparencies or mounted against a reflective background and can be made up to poster size. They are viewed with an inexpensive pair of polarized lenses made for stereo viewing. Regular polarized sunglasses will usually not work because the lenses are mounted at the wrong angle of polarization. Colors are truer than anaglyphs, and when properly lit, they look very real.

**Stereo-photogrammetry:** Stereo-photogrammetry is based on the concept of stereo-viewing, which derives from the fact that human beings naturally view their environment in three dimensions. Each eye sees a single scene from slightly different positions. The brain then "calculates" the difference and "reports" the third dimension.

**Stereoplexing (Stereoscopic multiplexing):** A means to incorporate information for the left and right perspective views into a single information channel without expansion of the bandwidth.

**Stereoplotter:** An instrument for plotting a map or obtaining spatial solutions by observation of pairs of stereo photographs.

**Stereopsis:** The binocular depth sense, literally, ""solid seeing." The blending of stereopairs by the brain. The physiological and mental process of converting the individual LH and RH images seen by the eyes into the sensation and awareness of depth in a single three-dimensional concept (or Cyclopean image).

**Stereopticon:** Term sometimes (erroneously) used to describe a stereoscope. First used (1875) to identify a dissolving twin-image magic lantern which could be used to convey information about depth by the blended sequential presentation of a series of planar views of a subject; later applied to some other kinds of non-stereo projectors.

**Stereo-restitution:** Process that uses two-dimensional information contained in a pair of images to recreate the shape and position of objects.

**Stereoscope:** A binocular optical instrument for helping an observer obtain the mental impression of a three-dimensional model when view plano-stereoscopic images (stereograms). The design of stereoscopic instruments use a combination of lenses, mirrors and prisms. It is usually an optical device with twin viewing systems.

**Stereoscopic:** "Solid looking". Having visible depth as well as height and width. May refer to any experience or device that is associated with binocular depth perception.

**Stereoscopic 3D:** Two photographs taken from slightly different angles that appear three-dimensional when viewed together.

**Stereoscopy:** The art and science of creating images with the depth sense stereopsis. The reproduction of the effects of binocular vision by photographic or other graphic means. Stereography.

**Strabismus:** "Crossed eye", "wall eye", "wandering eye", esotropia, exotropia, hyperphoria. Affects approximately 4 out of every 100 children in the United States. It is a visual defect in which the two eyes point in different directions. One eye may turn either in, out, up, or down while the other eye aims straight ahead. Due to this condition, both eyes do not always aim simultaneously at the same object. This results in a partial or total loss of stereo vision and binocular depth perception. The eye turns may be visible at all times or may come and go. In some cases, the eye misalignments are not obvious to the untrained observer.



**Stretch:** The elongation of depth in a stereogram in relation to the other two dimensions, usually caused by viewing from more than the optimum distance, especially in projection. The opposite effect to squeeze.

**Strip of stereo photographs:** A series of overlapping photographs taken while moving the camera in one direction and at regular intervals so as to generate a sequence of stereo images.

**Surround:** The vertical and horizontal edges immediately adjacent to the screen.

**(t):** In stereoscopy, t is used to denote the distance between the eyes, called the interpupillary or interocular distance. tc is used to denote the distance between stereoscopic camera heads' lens axes and is called the interaxial.

**Tautomorphic image:** A stereoscopic image which presents the original scene to the viewer exactly as it would have been perceived in life; ie, with the same apparent scale, positions of scenic elements, and a stereo magnification of x1 for all subject matter in the view.

**Taxiphote viewer:** A form of cabinet viewer devised by the Jules Richard Company for viewing a collection of stereograms in sequence, and continuously.

**Teco Nimslo:** A camera that uses the Nimslo format but has been modified by Technical Enterprises to expose only two frames per exposure as opposed to the four frames per exposure needed for lenticular processing.

**Theater Space:** The region appearing to be in front of the screen or out into the audience. Can also be called audience space. Images with negative parallax will appear to be in theater space. The boundary between screen and theater space is the plane of the screen and has zero parallax.

**Therapeutic 3D viewing:** 3D viewing for the sake of improving important visual skills such eye teaming, binocular coordination and depth perception.

**Tissue:** In stereo usage, an early type of stereogram on translucent paper in a card frame, often tinted and sometimes with pin-pricked highlights designed for viewing with backlighting.

**Toeing-in:** The technique of causing the optical axes of twin planar cameras to converge at a distance point equivalent to that of a desired stereo window, so that the borders of the images are coincident at that distance (apart from any keystoneing which results).

**Tracking:** A 3D tracking system is used in virtual reality in order for the computer to track the participant's head and hands. There are many different types including optical, magnetic and ultrasonic tracking systems.

**Traditional photogrammetry:** The use of film photography (usually diapositives) with analogue or analytical stereoplotters.

**Transcoding:** The process of converting one 3D video format into another. Example field sequential 3D video into column interleaved image data.

**Transposition:** The changing over of the inverted images produced by a stereo camera to the upright and left/right presentation necessary for normal viewing. May be achieved optically by means of a transposing camera or viewer, or mechanically by means of a special printing frame, as

well as manually during the mounting of images.

**Tru-Vue:** Proprietary name of a commercial stereo transparency viewing system that presents a series of views in a film-strip sequence on a single card mount.

**Twin camera stereo photograph - Fed 50:** Stereo photography using two monoscopic cameras, usually with shutters and other components connected internally or externally using mechanical or electronic means. This photography has advantages that include using common formats (e.g. full frame, medium format...) and being able to achieve a variable stereo base. Drawbacks include difficulty matching cameras, film and getting normal stereo bases. Camera bars can be used to help achieve more consistent results. (<http://www.berezin.com/3d/cameras.htm>)

**Twist:** Rotational displacement of one view in a stereo pair in relation to the other.

**Vectograph:** A form of polarization-coded stereogram (originally devised by the Polaroid company) in which the images are mounted on the front and rear surfaces of a transparent base, and are viewed by polarized light or through polarized filters. The polarized equivalent of an anaglyph stereogram.

**Verascope format:** See *Progression format*.

**ViewMagic:** Proprietary name of a commercial stereo print viewing system (utilizing angled periscope-type mirrors) for over-and-under mounted prints; the name now also being used to identify this mounting format.

**View-Master:** Proprietary name of a commercial stereo transparency image display and viewing system utilizing stereo pairs (7 in total) mounted in a circular rotating holder, and viewed with a purpose-made stereo viewer.

**View-Master personal format:** The format used with a Viewmaster Personal Camera. It produced 2 rows of chips of around 18 x 10mm per roll of 35mm film. These were used in conjunction with a cutter to make View-Master reels for personal use. It is not the same method that is used for mass-market reels produced by Fisher Price. (<http://www.berezin.com/3d/images/vmreel.jpg>)

**Virtual reality:** A system of computer-generated 3D images (still or moving) viewed by means of a headset linked to the computer that incorporates left-eye and right-eye electronic displays. The controlling software programs often enables the viewer to move interactively within the environment or 'see' 360° around a scene by turning the head, and also to "grasp" virtual objects in the scene by means of an electronically-linked glove. Although they allow you to see all sides of an object by rotating it, you are still seeing only two dimensions at a time.

**Vision:** The act of perceiving and interpreting visual information with the eyes, mind, and body.

**VRML:** Virtual Reality Markup Language. A set of standards for spinography software. Images are not really VR.

**Wheatstone stereoscope:** A "reflecting" or mirror stereoscope in which a pair of images (which need to be reversed) are placed facing each other at either end of a horizontal bar and viewed through a pair of angled mirrors fixed midway between them. Named after Sir Charles Wheatstone who devised this earliest form of stereoscope in 1832, prior to the advent of photography.



**Window:** The stereo window corresponds to the screen surround unless floating windows are used.

**Z-Buffer:** The area of the graphics memory used to store the Z or depth information about rendered objects. The Z-buffer value of a pixel is used to determine if it is behind or in front of another pixel. Z calculations prevent background objects from overwriting foreground objects in the frame buffer.

**ZPS:** Zero parallax setting or the means used to control screen parallax to place an object in the plane of the screen. ZPS may be controlled by HIT, or toe-in. We can refer to the plane of zero parallax, or the point of zero parallax (PZP) so achieved. Prior terminology says that left and right images are converged when in the plane of the screen.