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Stereoscopy.

Whether through photographs, drawings, synthetic images or images made by any other means, the principle remains the same: it is a matter of making two views of the same scene.

In photography.

We take the left and right views, respectively, from two side-by-side views. If the two points of view have the same spacing as the two eyes, the image may, under the right conditions of observation, be seen at its normal size; but we can take two views of points closer together, to represent small objects. They may also be taken from two more distant points of view, to represent mountains or formations of clouds: the result is what is called the effect of a model.

In two times..

This is the method Americans call "cha-cha".

In two steps, moving the camera: in this case, it is essential that nothing has moved between the two shots, for example characters, animals, vehicles, tree leaves, waves, clouds or their shadows under the effect of wind; it is also necessary that the two photographs aim in the same direction, that the camera has not advanced, has not been moved in height or turned on itself. There are commercial kits for cameras including a rail that can be fixed on a tripod in order to stabilize the camera. They can also act more safely and quickly than they do on the fly.

In 2012, Panasonic incorporates in its Lumix DMC-TZ30 a function that allows to take successively the two photos freehand. The photographer keeps the finger pressed on the shutter button while moving the camera horizontally (10 cm in 4 seconds) in front of him. An algorithm selects the two most appropriate stereoscopic pictures from all those taken during the trip. The file of the two interlaced photos is in MPO format. But this only works if nothing has moved in the meantime, so it does not provide anything more than the two-step method.

Simultaneous triggering.

Two identical devices can be triggered, film devices or digital devices; the devices are fixed on a rigid support and aligned, the objectives being parallel and pointing towards the same direction without convergence. Three techniques exist: the "digitale", literally, "with the fingers", where the shooting of each of the two devices is triggered the most simultaneously possible; the mechanics, with a more precise simultaneity, assured by the mechanics of a set of pistons, these two methods being valid for digital and film. The third method is electronic / electrical. The best known / practical / accessible is to connect two devices by a wired or aerial remote control, either by internal wiring in the devices (what Jacob van Ekeren did), or with USB, electric or infrared receivers (and other radios, eg bluetooth) of digital apparatus; the most effective device in this sense is StereoData Maker.

Film units with wired remote control triggering are suitable. In some cases, both devices operate without knowledge of each other (or others), in others, they are coordinated. Several artisans proposed couplings of two or more digital apparatuses, silver, well fixed and synchronized.

The synchronization must be all the more precise because there is something in the field that moves faster, especially laterally: for example a car can travel in one thousandth of a second half the interval between the two objectives, so be seen far ahead of the trees that line the road so should hide it in part.

Stereoscopic equipment.

A special camera with two lenses can be used: either a very old camera, with the usual constraints of very old apparatuses (absence of cell and automatic advancement of the film), or with a more modern apparatus, of which manufactures existed in small and medium format until very recently, notably by the German firm RBT. Since the end of 2009, the manufacturer Fujifilm offers the first consumer digital stereo device: the Finepix REAL 3D W1.

The camera has two lenses (and two sensors) at a distance of 77 mm, a little more than the average interocular space. At the same time, each

sensor takes a picture, and a file of type .MPO, containing the two photos, will be saved.

And in 2010 releases its successor, the Fujifilm Finepix REAL 3D W3 which allows stereoscopic video recordings in 1280x720 format But production has ceased. This camera was far from perfect, its sensors too small required good lighting, and when the lighting was too strong, nothing could be seen on the sighting screen, and there was no optical sight. Several companies also offer a wide range of accessories for stereoscopic stereo shooting (25mm camera base) or stereo (225mm) 3/1 relative to the camera's 75 mm camera base.

Other companies have taken out stereo cameras, especially in video, but most often with bases (spacing of lenses) too narrow for the usual uses. In 2011, Nintendo released the Nintendo 3DS, a gaming device that allows 3D auto-stereoscopic 3D images to be taken and displayed (directly on the console) in 3D in the form of . MPO images.

At the end of 2011, the Panasonic Lumix 3D1 arrives, with a distance between 30 mm lenses, which makes it possible to photograph a subject at less than one meter (Fujifilm W3)

In addition to the W3, the 3D1 has optical stabilization, wider zoom, and better image quality.

Visualization: With software such as StereoPhoto Maker, it is then possible to display the photo in relief using different techniques such as the anaglyph, the interlace (for polarized screens), the cross vision, or the parallel vision for which one finds in trade many models of stereoscopes, some of them, in cardboard, are very affordable for a decent quality.

Users of recent Macs (64-bit processor, OS 10.6) can also use StereoPhoto Maker with the free PlayOnMac software.

There are still other methods, each adapted to particular cases, in particular for shooting in "macro stereoscopy", that is to say with a narrow "base" suitable for photographing very small objects: double diaphragm with mirrors, image dividers (attention to "trapezoidal deformations"), side-by-side color filters in front of the lens, semi-transparent mirrors, etc.

Stereoscopic images can easily be extracted from all kinds of three-dimensional professional digital models, choosing two viewpoints separated, for example, by one tenth of the distance from the foreground, if it is to present them on a computer screen , but not more than one-thirtieth if they are to be presented to a large audience.

Another particular case concerns planetary photography (notably with Jupiter).

The rotation of the planet on itself is such that two images taken about a quarter of an hour apart from the Earth present the same shifts as two images of a sphere taken at the same time, much closer and two different points of view.

It is then possible to mount a stereoscopic image from these two planetary images taken with the same objective. The time lag and the rotation of the planet replace the distance between the two objectives, which here should have been an astronomical distance. Similarly, the Moon was photographed in relief, taking advantage of its movement of "libration", with an interval of time of a few months.

These images can be viewed in slides, pulled on paper, on the computer screen, on a 3D TV screen, etc., by different methods.

With an optical instrument called stereoscope.

There are several varieties: two lenses, two mirrors, a single mirror, a semi-transparent mirror, and so on. By separating the left and right views by the colors (anaglyphs): certainly this process degrades the colors and excludes the presence of brightly colored objects too close to those of the color filters, but it is the only known way to print images large format easily visible in relief by people not trained to free vision.

More modern systems, such as Infitec filters, use the same color filtering principle as anaglyph glasses with lesser color degradation. This Infitec system divides the color spectrum into six bands and not in two as the anaglyph system.

The Infitec system is now commercially operated for Dolby movies. Omega filters with eight bandwidths have also been marketed, but appear to be less efficient than Infitec filters, because the colors close to red are not seen at all through one of the filters.

Network Images.

Nested images in vertical bands: "lined" or "lenticular" networks, visible in relief without any instrument (self-stereoscopic method). Stereoscopic auto monitor: a monitor using lined or lenticular arrays to send each image to the corresponding eye and produce the stereoscopic effect.

Polarized images.

Projection in polarized light, by far the easiest, most effective and spectacular method, which certainly requires means for the organizers of these projections (metallized screen, two projectors with polarizing filters), but which impose spectators only to wear spectacles light, passive, inexpensive and non-restrictive polarized; the colors are not deteriorated at all and there is no risk of perturbation of the relief by the time parallax.

Because the Real 3D cinema system requires only a digital projector that alternates its circular polarization with a special disc placed in front of the projector, spectators wearing circular polarized glasses have made this type of projection a little less restrictive unless objects animated by rapid lateral movements are visible: then the temporal parallax effect degrades the perception of the relief.

3D televisions "passive", the same principle and almost the same image quality as the projection in polarized light to the detail that it is a monitor that simultaneously diffuses the two images, glasses polarized glasses (or glasses with circular polarization) are therefore also necessary.

There are two types of polarization: linear polarization (oblique to 45 °, commonly used in projection) and circular polarization, commonly used in televisions or 3D monitors.

In the latter case, the slab of the monitor is coated with a filter which polarizes the lines of even and odd pixels in each direction. These polarized lines are filtered by the lenses of the glasses. This process is used by some manufacturers, including Zalman since 2008 on Trimon monitors, and especially LG on screens much larger and less sensitive to the height offset of the viewers compared to the center of the screen.

At the moment, there are new active screens that allow to see in relief without glasses, thanks to lenticular networks glued in front of the screen.

For example, those of the French company Alioscopy, produced using 1920x1080 (full HD) resolution images, with 4k resolution screens or more recently 8k screens, in which software creates eight images of different points of view at from the two usual images, which allows more than ten people to see in relief without glasses, at the same time on the same screen. It is likely that within a few years some televisions will be equipped with such a system.

Alternative method.

This is characterized by the use of alternating liquid crystal glasses called Shutter glasses.

This method can be used with monitors, televisions or projectors. The method consists in alternating the two images on a screen synchronously with the transparency of each of the spectacle lenses, leaving only a short delay between the changes of image. This change is all the less noticeable to the naked eye (retinal persistence) as the frequency is high (at least 60 pairs of views per second), hence the impression of looking at the two images at the same time.

Some companies have tried to commercialize solutions to see sequential 3D video films (the left image displayed by the first field and the right image by the second field) on a cathode-ray television. But the frame rate of 60 Hz (each second thirty left and thirty right) in the NTSC area and worse than 50 Hz in the PAL area made the experience unpleasant.

As early as 1999, NVidia had marketed for its tnt and tnt2 cards with the ELSA Revelator glasses with a refresh rate ranging from 50 to 144 Hz depending on the capacities of the CRT monitors of the time.

But the refresh rates still too low (the most common ones were the 1024 * 768 in progressive 85 Hz and the 1280 * 1024 in 70 Hz progressive) of the consumer monitors made the visual experience still tiring over time although effective. Since 2007, Nvidia has been selling a 3D Vision kit suitable for LCD screens that can produce images with 120 Hz frequencies (60 Hz per eye).

The display of the right and left images is synchronized with the glasses using an infrared emitter.

But the alternating presentation presents two major drawbacks: it is incompatible with scenes in which there are somewhat rapid lateral movements, and it is incompatible with projection on a large screen,

unless a preliminary processing of the images has made it possible, advance the window.

Thus precautions must be taken to present films or video in this way: the sequence of images must be identical to the observation sequence.

It is not possible, for example, to present, in an alternating regime, sequences whose left and right views have been taken at the same time; otherwise, by a temporal parallax effect, any object in lateral motion will be seen at a false distance; if the movements are too rapid, the relief is no longer even perceptible.

On the other hand, if images are to be presented on a large screen (more than two meters in width), then there is a great risk of arriving at an obligation of ocular divergence for the spectators, if we have not taken the precaution of trim the left edge of each left view and the right edge of each right view if the images were prepared for presentation on a smaller screen, such as a 3D TV. Indeed, projection on a large screen with two projectors in polarized light makes it possible to bring the whole image closer or closer, thus adjusting the parallax of the backgrounds to a value close to the interocular distance of the spectators , which is not possible in alternating projection.

Other methods.

Real images projected in space, photostereosynthesis, holography, etc.

In free vision, parallel or crossed, for those who can, either spontaneously or after ocular exercises.

For some, this free vision is only possible at a significant distance, hence the image appears somewhat stretched. Cross vision is sometimes more accessible: the left eye looks at the right figure and the right eye looks at the left figure.

To help, the left eye can be closed and the right hand placed a few centimeters from its right eye, so as to hide the right figure. Then the right eye closes and the left hand is placed a few centimeters from the left eye so as to hide the left figure. Then the two eyes are open, each one seeing only a figure.

Sink somewhere in the gap between the two hands to make the two figures superimpose into a single figure.

The ability to see freely varies widely according to the person:

Some (a minority) arrive there easily, either in parallel or in crosses, even for a few in both directions; others arrive after training; others at least not at all: for these, it is useless to insist.

Concept of window:

The window is the stereoscopic image of the respective outer contours of the left view and the right view.

The window is therefore part of the image. It is not necessarily rectangular, nor necessarily parallel to the plane of the support of the image, nor even necessarily plane.

It always exists, unless the edges of the image merge with the outside: black background uncut in the case of a projected image, white background uncut in the case of a drawing on white paper.

In the case of a small screen (computer screen, 3D TV) the window can be constituted by the screen; on the contrary in the case of a public projection on a large screen (more than 1m50), it is imperative to converge the projectors to place the window well ahead of the screen.

The gushing.

What is seen in front of the window is said to gush.

This outburst is often spectacular, at least if it does not exceed the limits of the variation of depth currently accepted, and especially if it does not reach the lateral edges of the image: in the latter case there would be a violation of window, constituting a contradiction between various indices of depth: the gushing object is cut by the window thus seen behind it, but because of its parallax it is seen in front of the window: this situation is very tiring for the spectators.

Source of visual fatigue.

Contradictions between monocular and binocular depth indices, in particular due to incorrect placement of the window: if an object is cut by a lateral edge of the window (defined as the stereoscopic image of the outlines of the left and right) but because of its parallax, it is in front of this window, this constitutes a contradiction between indices of relief.

Contradictions between depth indices can also be caused by timing errors, a time parallax by which an object that has moved to the side is no longer seen at its proper distance if the left and right shots are not properly synchronized or if the frequency is doubled in alternating regime by successively repeating two left frames and two frames on the right or more generally if the sequence of presentation of the left and right views is not identical to the sequencing sequence.

Left and right views too disparate (eg colors too bright in anaglyphs).

Vertical offsets, in particular due to misalignment during shooting, rotation or trapezoidal deformations due for example to the use of certain "image dividers" or excess convergence of the optical axes.
Excess depth of relief: it is advisable not to exceed a typical limit of parallax extreme deviation which is generally estimated at one thirtieth of the observation distance.

The effects of this excess depth can be manifested in three different, almost independent ways:

On the one hand by an excess of angular parallax variation between the first planes and the backgrounds: the limits currently accepted for the amplitude of this range of variation are about two degrees; on the other hand, by an obligation for the observer to diverge his ocular axes.

And finally, in some very rare cases, by too great a dissociation between the accommodation and the convergence of the eyes: the limits commonly accepted for this dissociation are of the order of half a diopter (or two degrees), but a considerably stronger dissociation, up to ten degrees, does not fatigue those who can thus see in free vision..

Excessive deformations of the image in magnification or stretching, especially if these deformations are variable from one object to another.

Movements that are too fast, especially towards the observer, which make the latter not have time to operate its binocular fusion before the image is replaced by another.

Most of these pitfalls can be avoided, in particular by a so-called "montage" work, in the case of slides, as well as prints on paper or digital photos, as well as digital video sequences.

Recent studies by the Russian VQMT team, led by Dmitriy Vatolin, have revealed major defects (vertical parallax, window violations, color disparity between left and right, etc.) in various relief films published in the form of DVD.

Most of the information on the principles of stereoscopic image, practical methods of realization and presentation of relief images have been published in associations' magazines: French Stereo Club (more than a thousand numbers since 1904)

in English: quarterly journal of the Stereoscopic Society of London, bimonthly American journal Stereo World, quarterly review Stereoscopy of the International Stereoscopic Union.

More than 500 books have already been written on the subject.

Bibliography established and maintained by Sam Smith.

The first one is that of Antoine Claudet, in 1853, the most famous The Stereoscope, by David Brewster (1856), which is a free download, the most convenient for the amateur The World of 3-D, by Jacopus Ferwerda (1986)

Since 2010 several books in French on stereoscopy have been published, in addition to many books in English:

Éditions Presses des Mines published the book L'image en relief, by Olivier Cahen, with details of the calculations of correspondence between the object and the image that is restored, a book supplemented by a CD-ROM containing many images in relief and numerous links to sites devoted to stereoscopy.

Editions Eyrolles have published the book Turning in 3D-relief by Fabien Remblier specifically dedicated to the techniques of 3D digital shooting.

The editions Eyrolles published the book The digital stereoscopy of Benoît Michel.

Movies.

3D Odyssey, documentary in relief of Philippe Nicolet devoted to the history of stereoscopy, 2007.

Armorican Suite.

Dramatic film which takes place at the university of Rennes 2, in a geography module devoted to stereoscopy.

Posted by Veronica IN DREAM at 10:01 AM