3D camera Parallax adjustments, the Stereo Window, and using attachments for Close-Up photography

The following explanation describes how the Parallax setting on 3D cameras operates, and how the adjustment affects the 3D image. This leads into a discussion about close-up work and how close-up lenses and attachments can improve the close-up capabilities of stereoscopic cameras.

Note: The specific behaviors and characteristics of Sony camcorder models HDR-TD10 and HXRNX3D1U and JVC models GS-TD1 and GY-HMZ1U are described, but the techniques apply to any stereoscopic camera that has a "Parallax Adjustment" or "Convergence control."

Conceptually, viewing a 3D image (or movie) is like looking through a window. The 3D scene appears mostly "behind" this "Stereo Window," which is formed by the bounds of the exactly overlapped left and right image frames.

The Parallax setting of a camera sets the distance from the camera to the "Plane of Convergence." Usually, when the recorded images are shown the frames that bound the left and right images are aligned so that they exactly overlap on the screen, which places both the Plane of Convergence and the Stereo Window on the screen. Subjects in the scene that are closer than the Plane of Convergence appear in front of the screen and subjects that are behind the Plane of Convergence appear behind the screen, thus the screen becomes the Stereo Window. The Stereo Window and the Plane of Convergence are important concepts of 3D photography, so understanding them is critical to making good stereoscopic illusions, motion or still.

Camcorder Parallax adjustment and the Stereo Window:

Images captured by a camera have a limited Field Of View (FOV). The FOV is defined by the size of the image sensor and the focal length of the lens. The extent of a scene covered by the FOV "bounds" the image captured, which appears inside a "frame." Typically the frames of both the right and left images that form a stereo pair are aligned to exactly overlap each other on the surface of the screen they are being shown on. In the usual case this common frame that bounds both the left and right images forms the frame of the Stereo Window that the observer is "looking through." As previously discussed the Stereo Window is usually positioned on the screen, but in some cases it may be "Floated" off the screen. The Stereo Window can be "Floated" by judiciously adding borders to the sides of the left and right image frames, however, in this discussion we will consider only the case where the Stereo Window is in the Plane of Convergence and on the screen. Note that the "Parallax Adjustment" is sometimes called the "Convergence Control," because the effect of adjusting the Parallax (or the Convergence) is to set the distance from the camera to the Plane of Convergence, or more tangibly, the distance from the viewer to the Stereo Window.

If objects in the scene appear (stereoscopically) in front of the Stereo Window, care must be taken to insure that they are "isolated" and do not "intersect" or "touch" the Stereo Window frame, particularly on the sides, otherwise a “Stereo Window Violation” will occur. Stereo Window Violations are visually very confusing and should be rigorously avoided. In order to avoid Stereo Window Violations the distance to the Stereo Window is usually set so that most of the objects in a 3D scene appear “behind” the Stereo Window. Note: Other techniques like fading or blurring the edges of the frame, or “Floating” the Stereo Window are also used to avoid the ill effects of Stereo Window Violations, but these subjects are beyond the scope of this document and will not be further discussed here.

The distance from the camera to the Plane of Convergence (or Stereo Window) is fixed for some cameras and adjustable in others. Fortunately this distance can also be adjusted in “post processing,” after the imagery is captured (unlike the” Z-Scale” which is determined by the lens spacing). Adjustment of the distance to the Stereo Window in post is not at all difficult for still images, but it can add a lot of complication to video post processing. Adjusting the Stereo Window in post will change the aspect ratio of the frame. This will usually necessitate some further cropping and/or scaling in order to maintain a consistent frame size and aspect ratio for the video. It’s always best if you can get it right, or at least close, when you capture the imagery.

The Sony camera calls the Parallax Adjustment the “Depth Control.” In manual mode it’s adjusted using the knob on the front of the camera. In automatic mode the Sony uses a “fixed” value for the distance to the Plane of Convergence which depends on the zoom setting. In both automatic and manual parallax adjustment modes, as you zoom in, the distance to the Plane of Convergence moves away from the camera. This may or may not be what you want, if it’s not you will have to correct it in post because there is nothing you can do about it on the camera (for this reason you may choose not to zoom during the shot). In automatic mode, at the camera’s “full wide” zoom setting the Stereo Window is set to about 23 inches in front of the camera. At half zoom the Stereo Window moves out to about 100 inches, and out to about 35 feet at full zoom. In manual convergence adjustment mode (Manual Depth Control) the distance to the Stereo Window can be set from infinity up to about 20 inches at full wide, infinity to 60 inches at half zoom, and infinity to about 200 inches at full zoom. The control is “very sensitive;” a small turn can shift the Stereo Window a great deal.

The JVC camera uses the term “Parallax Adjustment,” as does Fuji in its W1 and W3 model 3D cameras. The JVC camera also supports both manual and automatic modes for adjustment of the Parallax. In automatic mode the distance to the Plane of Convergence is set to be the same as the focus distance for subjects further than about 10 feet from the camera;iIt’s set to 10 feet for subjects closer than 10 feet. This puts the Stereo window at least 10 feet from the viewer in all cases when automatic mode is used, which might be too far, as it makes Stereo Widow Violations rather probable.

In manual mode on the JVC the distance to the Stereo Window is “fixed” at the set value; if set “properly” it is independent of focal length of the lens (zoom setting), which seems to be quite a desirable feature of this camera. To insure that the set distance to the Stereo Window is independent of the zoom setting, set the camera to “full zoom” (longest focal length) before setting the parallax. If you set the parallax with the camera at “full wide” the distance to the plane of convergence may change when the zoom is operated (depends on the value it’s set too.) The range of manual adjustment of the distance to the Plane of Convergence on the JVC is from infinity to about 68 inches (at any zoom setting.)

For both the JVC and Sony cameras the distance to the Plane of Convergence is set visually by shifting the right and left images relative to each other so that objects at the Plane of Convergence (Stereo Window) overlap on the screen. Both cameras also display a number that represents the value of the setting. This number could actually be the distance to the Plane of Convergence, but it's notand appears to be a "unit-less" number. The JVC uses a special "mixed" display mode when the Parallax setting is active; this mode shows both the left and right images overlapped with transparency, so you can easily see what is overlapping and what is not. When you finish with the setting the screen reverts back to 3D mode. The Sony on the other hand has no special display mode for this purpose; instead you can move your view off of the "sweet spot" of the 3D display to see "ghosts" of both the right and left images instead of seeing a 3D image. Then you can see where they (the ghost images) overlap. Of course you might be able to "see" where the Stereo Window is positioned relative to objects in the scene in 3D, but it's usually easier to work with the "ghost" images. If you use the 3D method of viewing as you make the adjustment, it can help to frame the scene so the nearest object in the scene is close to one side of the frame, then it's easy to tell if the object is in front of or behind the window (frame).

The above discussion was included to help in understanding the range of subject distance over which the JVC or Sony 3D camcorders are useful. Several factors affect how "close" you can get to a subject to be photographed in 3D. Specifically, how close the lenses will focus, how far apart the lenses are, how much overlap there is between the right and left images (dependent on the range of convergence,) the position of the stereo window (convergence distance,) and the total depth of the scene (foreground to background.)

Close-up work using the JVC or Sony camcorders:

The rather narrow spacing of the lenses on both the JVC and the Sony camcorders (less than normal eye spacing) make these cameras well suited for close-up work, but other characteristics of these cameras limit how close you can actually get without using "attachments." The Plane of Convergence is the plane where there is 100% overlap in the right and left images across the entire frame. Objects that are closer than the plane of convergence may or may not entirely appear in both the right and left images. The same is true about background objects but the effect here is natural, it's like looking through a window, your right eye does not see as much of the right side of the distant scene as the left, because of occlusion by the window frame (try it!). In front of the window the objects must be totally within the window bounds or a Stereo Window Violation will be present, causing visual confusion. As a result objects in a stereogram are usually all "behind" the Stereo Window, or plane of convergence. Because of this the distance to the Stereo Window generally defines how close you can get to a subject.

Hence, if you can't bring a subject "through the window" (for instance because it is too big and will somewhere intersect the Stereo Window) the distance to the Stereo Window (Plane of Convergence) is as close as you can get to a subject being photographed.

As explained in the previous section, for the Sony the distance to the Plane of Convergence depends on the zoom setting and varies from about 20 inches (full wide) to 200 inches at full zoom. For the JVC the near limit is about 68 inches.

The real measure of how "close" one can get to a subject is the maximum "Magnification" possible with the nearest object in the scene positioned at the Plane of Convergence (or the Stereo Window.) As a measure of "Magnification" I will use the size of the image of an object on the camcorder screen relative to its actual size in real life. For the Sony with no attachments, the maximum magnification of an object recorded in 3D at the Plane of Convergence is 0.15X. The JVC is somewhat better in this regard, since the distance to the Plane of Convergence does not change with the zoom setting, however the zoom range is much smaller on the JVC than it is on the Sony. For the JVC, the maximum magnification is 0.23X. Note that the screen size is very nearly the same on both cameras at 77mm wide and 42mm high.

With the addition of a "close-up lens" both cameras can produce good 3D imagery with much greater magnification. There are generally four issues encountered when capturing near scenes with any stereo camera, they are:

1) **Close focus**: Some cameras cannot focus at near distances; the classical (2D) use of a close up lens is to enable close focusing. A single close up lens does this for both lenses when used with narrow base 3D video cameras.
2) **Image overlap**: As the lenses get closer to a subject, the common area of the scene imaged by both lenses is reduced. A single close up lens large enough to be used over both taking lenses helps solve this problem. The prismatic character of the close up lens, essentially used symmetrically "off axis" by each taking lens shifts the image center to the right for the left image and to the left for the right image, thereby increasing the common area of the scene imaged by both lenses. Higher "power" (shorter focal length) close-up lenses do this to a greater degree than low power lenses, so the ability to improve overlap correlates with the ability to focus closer. Note that by definition there is 100% overlap of the right and left images at the Plane of Convergence.
3) **Convergence**: In order to keep the subject "behind" the stereo window as the lenses get closer to a subject, the stereo window, or point of convergence must also get closer to the lenses. The distance from the camera to the stereo window is set by the convergence control on the stereo camera, either manually or automatically. Practically (for the cameras discussed here) this control has a fairly limited range of adjustment and will not allow the stereo window to be moved close enough for close subjects. A (single) close up lens solves this problem in a similar manner to how it solves the image overlap issue. The prismatic character of the lens shifts the center of the right image to the left, and the left to the right, moving the Plane of Convergence closer to the camera.
4) **Stereo-Base, or interaxial:** As the stereo camera is moved closer to a subject, if the interaxial is left unchanged, the angle each lens makes with the subject increases. The difference between this angle for the nearest object in the scene and for the furthest object in the scene determines the "total deviation." The total deviation should be kept to less than about 6 degrees (some say 3 degrees) for comfortable viewing. While the close up lens does nothing to reduce the total

deviation, the interaxial of the aforementioned cameras (at about 30mm) are considerably smaller than “normal” (normal is generally considered to be the average eye spacing of about 65mm) making them “better” for close-up work than if they had a more “normal” stereo base. The total deviation may also be minimized by “backing up and zooming in;” this reduces the angle each lens makes with the subject for a given Magnification. Lastly, reducing the distance to the furthest object in the scene (total actual depth of the scene), or making sure the background has no “detail” that can be “fused” (plain colors or highly blurred) can help to reduce or eliminate the discomfort of excessive deviation.

Conclusions: The use of a single close up lens with a narrow interaxial stereo camera improves the close range of subjects that can be captured by solving issues 1 through 3 discussed above. Issue 4 can be handled by taking care in the composition of the scene.

Appendix A is a chart showing the useful range of the cameras supported by the Cyclopital3D FCA with and without the use of close-up lenses. Note the remarkable increase in Magnification made possible by the use of even the lowest “power” (+1) close-up lens.