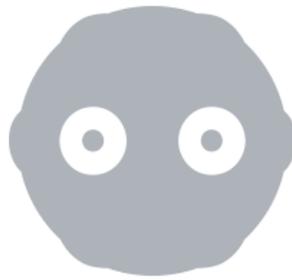


OZO



# TIPS FOR IMPROVING IMAGE QUALITY ON OZO FOOTAGE

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References Creator v1.5.0

# Overview

This document will concentrate on using **OZO Creator's Image Parameters** to address temporal noise and color/chroma artifacts, as well as using the **Neat Video** plugin to address temporal noise. Please note that many of the general noise reduction suggestions and techniques described here apply to a number of 3<sup>rd</sup> party noise reduction solutions.

Depending on how optimal the lighting conditions are during a shoot, and how well the **Exposure** control in **OZO Remote** is set (please refer to the **OZO Exposure Manual** for more information), the imagery may contain more temporal noise than desired. Additionally, in high-contrast, high-frequency areas of the image, and in darker, more compressed areas of the image, color/chroma artifacts may be seen. **OZO Creator's Image Parameters** are a means of addressing such image defects.

The document assumes familiarity with the usage of the **Neat Video** plugin in your given application and is not meant as a replacement for the user guides and documentation supplied by ABSOFT. If any issues specific to Neat Video are encountered, please contact [ABSOFT support](#) for assistance.

## Improving Imagery Using OZO Creator

When exporting imagery from a raw capture, it is encouraged to use OZO Creator's image processing filters to improve the quality of the imagery.

The controls for these filters are located in the metadata tab of each individual raw capture under the **Image Parameters** heading. The parameter values are saved on a per-asset basis, so it is easy to tailor these settings for all of the different raw captures in a project. These per-asset settings will also be retained when the project is saved.

The effects of the settings are visible in fisheye and stitched imagery, viewed either on a monitor or in an HMD.

*Please note that it will take a moment after releasing the mouse button for OZO Creator to process the adjustments made to these parameters. So, there will be a short delay between setting a value, and the image updating with the results of that change.*

## Exporting Filtered Imagery

The parameters selected on a given raw capture and the results seen in OZO Creator will be applied to *most* formats of imagery and any depth maps exported from the capture.

The **Temporal denoise** filter is the only filter whose effects can be seen in *all image exports, including exported DNG files*.

In contrast, the effects of the **Luminance denoise** and **Color denoise** filters and the **Saturation** control can only be seen in the DPX, EXR, MP4, and MOV files. These filters are *not* applied to DNG files.

## Reducing Color/Chroma Artifacts with the Color Denoise Filter

The **Color denoise filter** is used to remove saturated “false-color” chroma artifacts which can often be seen on the edges of high-contrast, high-frequency detail.

- The **Color denoise strength** parameter adjusts the aggressiveness of the filter. Higher values will more aggressively remove these artifacts, but this may also increase the desaturation of the real image content. This parameter defaults to a value of **40**.
- The **Color denoise radius** controls the size of the filter. Larger values will remove “blotchy” lower-frequency (larger-sized) chroma artifacts more thoroughly. These are often seen in darker areas of the image. Please note that larger values will also desaturate more and larger regions of real image content. The smaller values remove the high frequency color artifacts caused, e.g., by aliasing on complex detail in high-contrast conditions. This parameter defaults to a value of **1**.

In some cases, increasing the **Saturation** parameter can be used to help compensate for the high-frequency-desaturating effect of the Color denoise filter.

The parameter selected on a given raw capture and results seen in OZO Creator will be applied to any converted imagery and depth maps exported from the capture. *However, the image processing filters will not be applied to the DNG exports, as DNG files are raw sensor data.*

## Reducing Color/Chroma Artifacts with the Color Noise Filter

The **Color Noise Filter Strength** adjusts the aggressiveness of the filter that reduces chroma artifacts. These saturated “false-color” chroma artifacts can often be seen on the edges of high-contrast, high-frequency detail. Higher values will more aggressively remove these artifacts, but this may also increase the desaturation of the real image content. This parameter defaults to a value of **40**.

The **Color Noise Radius** controls the size of the **Color Noise Filter**. Larger values will remove “blotchy” lower-frequency (larger-sized) chroma artifacts more thoroughly. These are often seen in darker areas of the image. Please note that larger values will also desaturate more and larger regions of real image content. This parameter defaults to a value of **1**.

In some cases, the **Saturation** parameter can be used to help compensate for the desaturating effect of the Color Noise Filter.

Experiment by adjusting one parameter at a time for best results.



Chroma/color artifacts visible in tree branches. Color denoise Filter turned off.  
Chroma/color artifacts visible in tree branches. Color Noise Filter turned off.



Chroma/color artifacts reduced using Color denoise Filter

## Reducing Noise and Compression Artifacts with the Temporal Denoise Filter

The **Temporal denoise** filter in OZO Creator applies a denoise process which utilizes information from multiple adjacent frames (i.e. a *temporal* process) to reduce the random noise in imagery.

*On static detail*, this filter can do an excellent job at significantly reducing noise without softening the image. But, if set too aggressively, *this filter may “smear” or soften detail that is in motion from frame to frame.*

It is recommended to rely primarily on the **Temporal denoise** filter when removing random noise in the image. When set properly, this filter will provide significant noise reduction, while also preserving the maximum amount of detail and sharpness in the footage.

- The **Temporal denoise strength** parameter adjusts the aggressiveness of the filter. This parameter primarily determines *if* noise is removed. Higher values are more aggressive, and lower values are less aggressive. The higher the value, the more frame-to-frame variation in pixel values the algorithm accepts when removing noise. Please note if the value is set too high, too much variation may be allowed, and artifacts may appear in some content. Also note that if the value is too low, the algorithm may interpret the frame-to-frame random noise as movement, and the filter becomes less effective. This parameter defaults to a value of **40**.
- The **Denoise framecount** parameter adjusts the number of frames used to reduce the noise. This parameter primarily determines *how much* noise is removed. Higher values equate to potentially lower noise levels. So, under typical circumstances, it is recommended to set this value as high as possible. This parameter defaults to a value of **10**.

With properly exposed footage, the default values, or even a slightly reduced **Temporal denoise strength** value, should suffice. But if the footage contains the challenging combination of significant motion *and* significant noise, then reducing the **Denoise framecount** value (to minimize the visibility of possible smearing) and utilizing a higher **Temporal denoise strength** value (to maximize capturing high-intensity random noise) may be the best combination of settings.

One final critical detail to note is that *the Temporal denoise filter does not apply noise reduction to the first frame of an asset*. Position the playhead several frames into the timeline to ensure that the full effect of the filter can be seen when adjusting values.

## Reducing Noise and Compression Artifacts with the Luminance Denoise Filter

The **Luminance denoise** filter in OZO Creator applies high-quality spatial filtering that can be used to reduce both compression artifacts and temporal sensor noise. This filter is applied to imagery *after* the Temporal denoise filter is applied. *So, ensure that the Temporal denoise filter parameters are optimized prior to adjusting the settings for the Luminance denoise filter.*

- The **Luminance denoise strength** parameter controls the aggressiveness of the filter. Higher values will more aggressively remove noise. But higher values also increase the possibility of softening image detail.

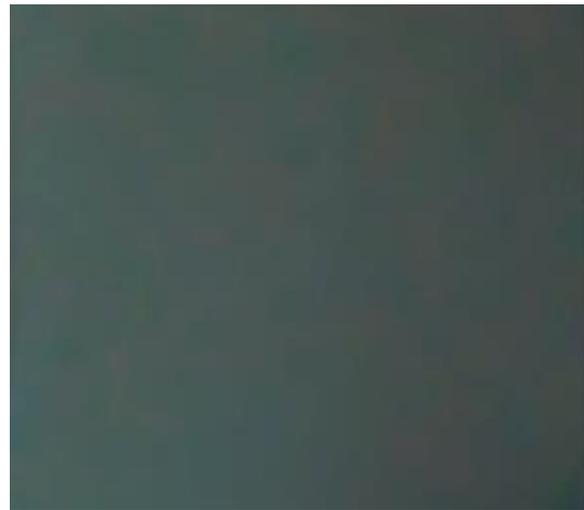
## Reducing Noise and Compression Artifacts with the Luminance Noise Filter

The **Luminance Noise Filter** in OZO Creator applies high-quality spatial filtering that can be used to reduce both compression artifacts and temporal sensor noise.

The **Luminance Noise Filter** parameter actually controls two filters, one or both of which are utilized depending on the value of the slider. Lower values primarily utilize a filter which helps reduce the visibility of compression artifacts. Higher values additionally utilize a more traditional spatial noise filter which helps to reduce the intensity of random noise.



All filters turned off\*



Luminance denoise filter set to a maximum value of 100\*

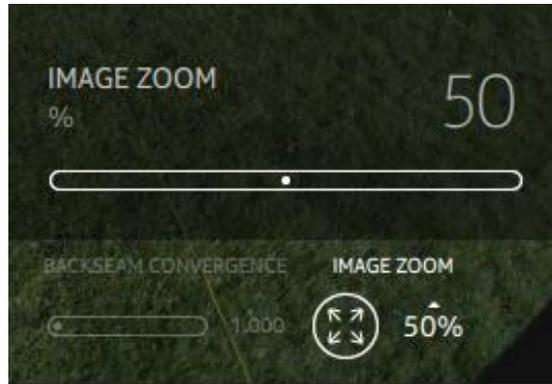
*\*images brightened to enhance visibility of noise*

## Evaluating the Effects of the Filters on Fisheye Imagery

To more closely inspect the results of these filters when adjusting the values, it is recommended to zoom in on the fisheye imagery using the **Image Zoom** control.

This is achieved either by zooming with the mouse when the cursor is placed over the image, or by clicking on the zoom percentage value to open an **Image Zoom** pop-up window, and then adjusting the slider. The maximum zoom value is 300%, which approximates the size of the imagery when stitched and viewed in an HMD. When zoomed in, the image can also be repositioned by clicking and dragging it.

*Please note that the Image Zoom window only works in **Fisheye** mode.*



The Image Zoom pop-up window

To close the pop-up window, click on the zoom percentage value.

In the Metadata tab, there are also controls for toggling the filters between user-set parameters and defaults, and for resetting the values to default.

- The  button is enabled when changes have been made to the parameters. Pressing this button will toggle the image between the original parameters and the adjusted parameters, so comparisons can be made between two different settings to assist in finding optimal values.
- The  button will reset the parameters to their default values. This is only enabled when changes have been made to the parameters.

In addition to improving image quality, these image processing filters can also improve the results of the optical flow used in the **High (slow)** stitch in OZO Creator and in the generation of depth maps. So, it is recommended to optimize these parameters on each of the raw capture assets in a project, prior to stitching the assets or exporting depth maps using OZO Creator.

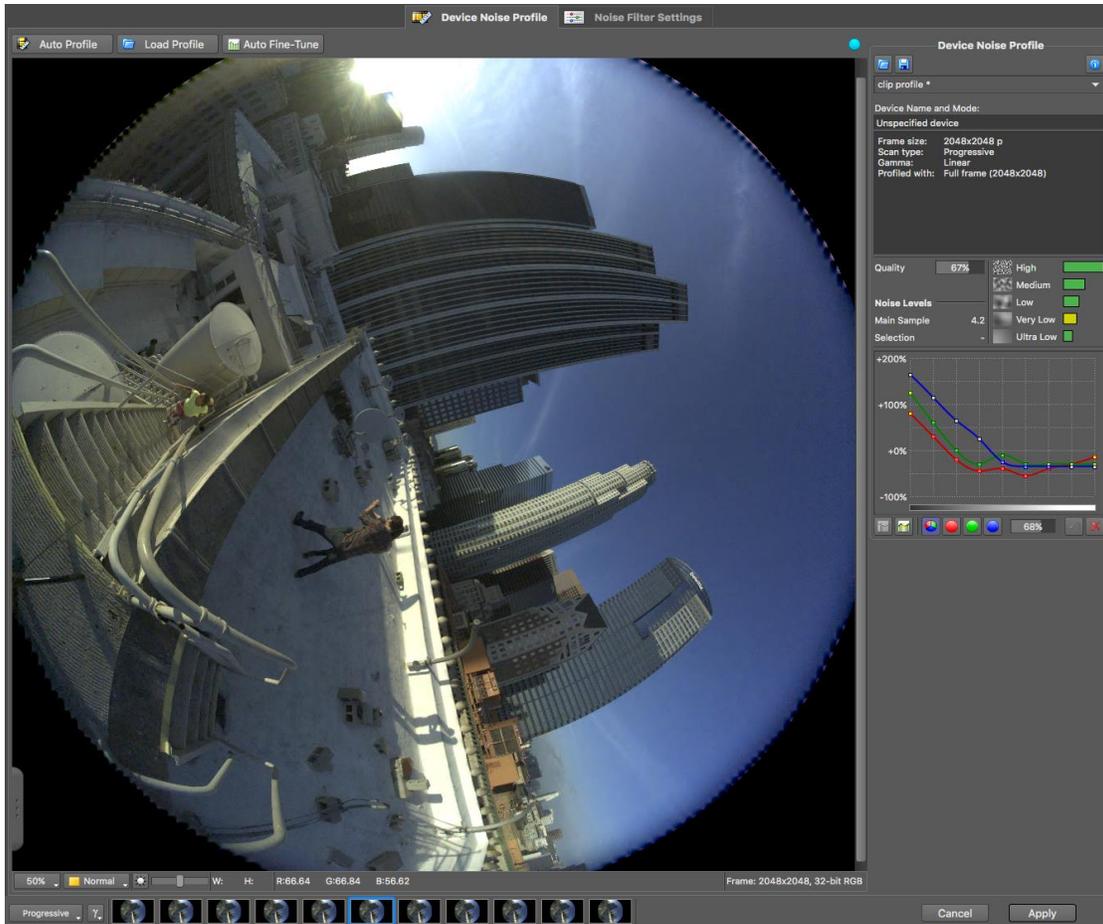
## Comparing the Results of Different Filter Settings on Stitched Footage

One way to quickly compare and contrast multiple different sets of parameters on stitched footage is to select the **Single frame (Playhead)** option in the Range menu of the Export Asset window. This selection works best when also enabling the **Import stitched image assets automatically once exporting finishes** option available in the Job Queue window.

- Adjust the **Image Parameters**
- **Export** Stitched DPX or EXR using the **Single frame (Playhead)** option
- For easy reference, name the file using a **Custom** name that reflects the chosen settings
- **Queue** the job
- Repeat until all desired variations of Image Parameters have been queued for rendering.
- After opening the **Job Queue**, but before executing the queue, ensure that the **Import stitched image assets automatically once exporting finishes** option is selected

Using this procedure, a number of these jobs can be queued, and then automatically imported into the list of Stitched assets in OZO Creator upon completion of the queue. The resulting single frame versions with different Image Parameters can then be compared within the Creator UI, or optimally using an HMD.

## Noise Reduction Using Neat Video



The Neat Video Noise Profile window with profiled noise curves

In **Neat Video**, a **Noise Profile** needs to be set up to help the plugin plot the noise intensity in each of the R, G, and B channels at varying luminance levels. This is required so that the noise reduction algorithm knows how aggressive it has to be to remove the noise throughout the image.

First, it is recommended to generate a **Noise Profile** and apply noise reduction to the fisheye images, and *not* the final stitched imagery. Stitched images are geometrically warped and distorted to fit an image meant for spherical projection. As such, the noise will be warped and distorted as well. This warped and distorted noise will complicate the noise profiling process and make it more difficult to remove the noise evenly throughout the stitched frame.

Since a fisheye image is the native geometry captured on the camera's sensor, the noise will be evenly sized and sharp throughout. Working on these individual images ensures a more accurate noise profiling process and eases noise reduction. This concept is not unique to **Neat Video**, and will hold true for any noise reduction solution.

Depending on the camera settings during production and the intended stitching solution, noise will need to be removed from four to eight fisheye images. Under normal circumstances, this process with OZO footage is quite similar to typical 2D footage.

## Creating a Noise Profile in Neat Video

For each shot, choose the imagery from a single sensor that appears the noisiest – as long as there are substantial “flat” areas visible to properly generate a good **Noise Profile**. Then create and save the **Noise Profile** for that sensor. By choosing the noisiest sensor, the most aggressive **Noise Profile** will be generated, which ensures more complete noise removal in all of the sensors.

*NOTE: If using EXR files with Neat Video in **Nuke**, ensure that **auto alpha** is enabled in the **colorspace** section of the **Read** node for the input files. Otherwise, only gray frames will be presented when attempting to **Prepare Noise Profile** in Neat Video.*

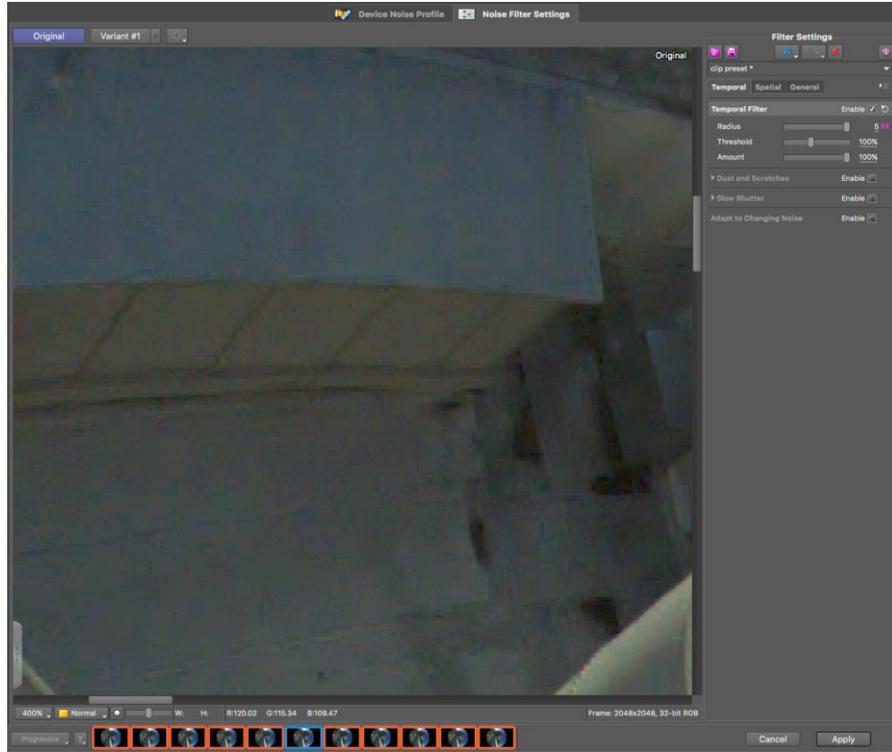
## Creating a Clip Preset in Neat Video

After a good **Noise Profile** has been generated, create a **Clip Preset** that adequately removes any offending noise in the same noisy imagery.

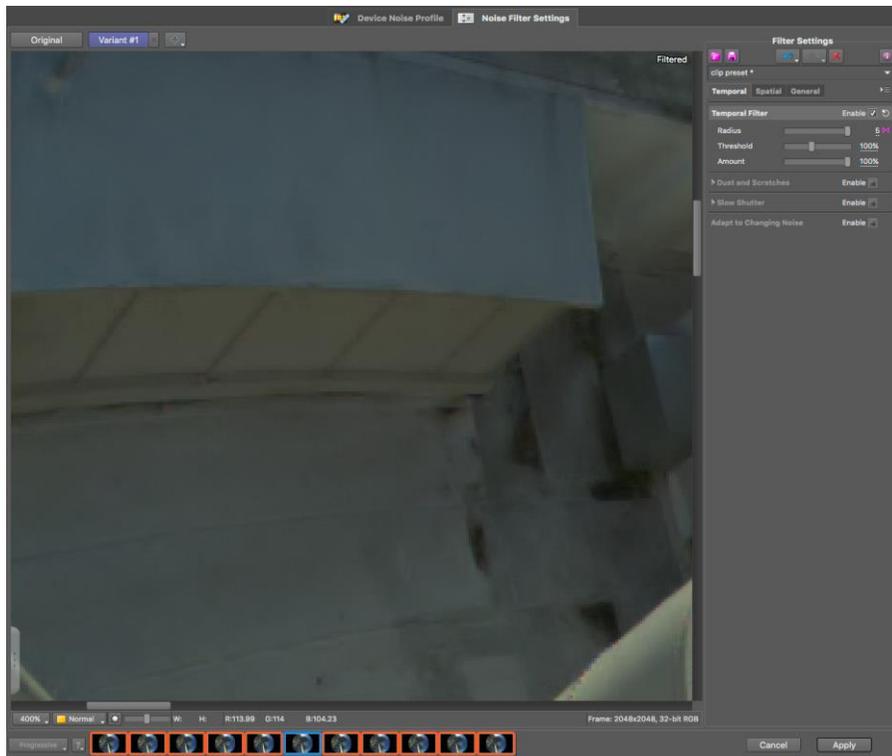
Concentrate on adjusting the **Temporal Filtering** and **Spatial Filtering**. If needed, adjust the **Artifact Removal**. Also try adjusting the **Quality Mode** to improve sharpness on image detail.

Use as much **Temporal Filtering** as possible, and minimize the amount of **Spatial Filtering** to preserve the image details, maximize the noise reduction, and minimize any compression artifacts. Then save the **Clip Preset**.

Finally, apply the same **Noise Profile** and **Clip Preset** to all of the per-sensor fisheye images and render out the image sequences.



Original image blown up to 400%. Note the inconsistency in the detail in the fine lines in the lower half of the image.



Noise reduced image blown up to 400%. Note how the temporal filtering has better defined the lines in the lower half of image.

## Noise Profiling / Noise Filtering Tips

Under normal circumstances, avoid creating a different **Noise Profile** for each lens. Secondly, do not use significantly different noise reduction settings for each lens. Because, in the end, all of these separate fisheye images must be stitched together into a single frame.

If there are significant differences in the noise reduction settings used on different lenses, especially different temporal window values (such as differing **Radius** values in **Neat Video**), it is likely that the per-sensor fisheye imagery will not match as closely in color and residual noise. So, after stitching, the final imagery may not be as visually “seamless” as desired, especially at the poles of the sphere.

Additionally, most automated stitching algorithms produce better results in the absence of noise. So, by reducing noise prior to stitching, the quality of the stitching itself may also be improved.

In **Neat Video**, setting the **Quality Mode** to **Slower/High** will reduce some softening from the temporal filtering in motion areas, and thus will help to maximize sharpness and detail. However, the improvements tend to be subtle and do not typically exhibit a night-and-day difference.

Also, in **Neat Video**, the following parameters on per-sensor OZO footage are most likely **not** needed:

- **Dust and Scratches**
- **Slow Shutter**
- **Adapt to Changing Noise**
- **Edge Smoothing**
- **Sharpening**

## Temporal filtering vs Spatial filtering

It may be useful to understand the conceptual difference between these two filtering techniques to know why this document recommends relying primarily on temporal filtering over spatial filtering.

**Temporal filtering** analyzes multiple sequential frames of footage to reduce noise. In other words, it filters using information over *time*, hence the term *temporal*.

It is optimal to first line up all of the detail in the images by tracking a number of surrounding frames to the “center” frame (i.e. the frame that is being noise reduced). This alignment is normally done on a per-pixel basis using an optical flow/motion estimation algorithm, so that each frame looks as identical to the “center” frame as possible. This process is sometimes referred to as “warping” the frames. Then a per-pixel average is taken across the “warped” frames and the “center” frame to output a noise-reduced center image.

However, it is possible that significant noise reduction can be done without utilizing motion estimation *and* without negatively affecting content that is in motion. The **Temporal denoise** filter in OZO Creator is an example of this.

Temporal averaging works because noise is random and different for each frame (“fixed pattern noise” notwithstanding). If the images are aligned well by the optical flow/motion estimation algorithm, and/or the software accurately recognizes when to and when not to integrate noise, then little-to-no detail is lost. In fact, details that are “hidden” in the noise, or that aren’t perfectly consistent on a frame-by-frame basis, can often become much more prominent after this process (as seen in the earlier image comparison).

In contrast, **Spatial filtering** uses information within a single frame to reduce noise. In other words, it filters using information across a certain *space* in an image, hence the term *spatial*.

Whereas temporal filtering uses adjacent *frames* to apply noise reduction, spatial filtering uses adjacent *pixels* within a single frame to apply noise reduction. The most common kind of spatial filter is a blur filter. While there are very sophisticated edge-aware, detail preserving spatial filtering algorithms available (such as the **Luminance denoise** filter in OZO Creator), any spatial noise reduction filter will negatively affect the sharpness and detail of an image to some extent (though high quality spatial filters will not affect image detail to the extent that a simple blur filter will). Spatial filters are typically used as a “fallback” when temporal filtering cannot accurately track and remove noise (e.g. fast motion).

In summary, when reducing noise, **Temporal filtering** that incorporates high-quality motion estimation/optical flow (as Neat Video does) will provide the *best chance of preserving image detail and sharpness*, while **Spatial filtering** will inevitably result in *some image softening*.

## Impact of Color Matching on Workflow

If color matching the per-sensor imagery is required, it is possible to apply noise reduction either before or after the color match process. However, the choice will likely have an impact on the workflow.

The simplest workflow would be to *profile and noise reduce prior to color matching*. Reasonable quality can be achieved by following this workflow.

Noise reducing *before* color matching can have the effect of adding contrast and visibility to residual noise that was previously much “flatter” and less noticeable.

*Applying color matching before profiling and noise reduction* may cause a need for a separate **Noise Profile** for each one of the lenses, since the color match process may affect the noise distribution differently in different lenses. The severity of this difference will depend on how extreme a color match is required. However, to minimize differences in color, luminance, or noise created by differing amounts of noise reduction, utilize the same **Noise Filter** settings (especially **Temporal Filtering**) as much as possible.

One advantage of noise reducing *after* color matching is having more confidence in the results of the noise reduction, since there will be less adjustment to color afterwards. Especially when considering the likelihood of further “creative” color grading on the final stitching imagery.

## Recap / General Noise Reduction Tips

- Utilize the **Color denoise filter** in **OZO Creator** to minimize chroma/color artifacts for a more natural-looking image.
- First optimize the settings for the **Temporal denoise filter**, prior to adjusting settings for the **Luminance denoise filter** when exporting footage from **OZO Creator**.
- Set the **Luminance Noise Filter** in **OZO Creator** to low values (*less than 50*) to reduce compression artifacts, and higher values (*greater than 50*) to additionally reduce random noise. The best noise reduction results are achieved when combining lower Luminance Noise Filter values with a 3<sup>rd</sup> party temporal noise reduction solution.
- Apply noise reduction to **per-sensor fisheye** images, and not stitched images. Stitched images will have the noise stretched and warped due to the geometric transform, and thus will complicate the process of accurately profiling and removing the noise throughout the frame. Also, automated stitching algorithms typically provide better results on noise-free imagery.
- In general, choose **one setting** to reduce noise for all the lenses in a given shot. Do not vary the setting from lens to lens if it can be avoided. This will ensure minimal color, luminance, and noise difference between the fisheye images, so that the stitched imagery is as visually seamless as possible.
- Maximizing the usage of **temporal filtering** (as compared to *spatial filtering*), optimally with motion estimation/optical flow (as compared to *spatial filtering*), will generally provide the best reduction of noise while preserving as much detail as possible. This is especially true on scenes with no camera motion. For example, when using **Neat Video**, select a high **Radius** value and as low of a **Spatial Filter: Noise Reduction Amount** as possible.
- If a shot consists of a very detailed scene where some compression is visible, then **temporal filtering** can help to **stabilize the temporal consistency** of the detail and thus **reduce the visibility of compression artifacts**.
- When possible, use the **best quality optical flow/motion estimation** settings available in the noise reduction solution. This will preserve the most detail and result in the most effective temporal noise filtering.
- It is generally **not recommended to use sharpening on fisheye images** (unless used very subtly), since it may introduce overshoots/over-sharpening that will be impossible to remove later. In general, it is best to save creative choices of this kind until after stitching the images. This avoids having to re-stitch (one of the most time consuming parts of VR production) if different creative choices are made after stitching.
- Applying noise reduction before color-matching lenses reduces the need to create separate **Noise Profiles** for each lens. Meanwhile, color-matching before applying noise reduction, which may require

the creation of separate **Noise Profiles** for each lens for optimal noise reduction, can provide for a bit more confidence in the noise reduced results if an extreme color correction is required to match per-sensor imagery.

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