VirtualDub and Video Astronomy
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Introduction:
Use of a video camera designed specifically for astronomy has greatly expanded my capabilities and enjoyment of the hobby. My Mallincam Xtreme has opened up a universe of deep sky wonders that I would otherwise never be able to observe from my home in central Ottawa due to the high level of light pollution. As part of my observing I always tend to save screen captures from the camera to keep as a record of what I observed. Using fairly simple image processing techniques I have been able to produce some nice images from those raw screen captures. Wouldn't it be nice if I could apply some of those same image processing tools directly to the live video feed from the camera?

Objectives:
I have searched around for a software tool that allows for basic image processing filters to be applied to a live video feed. In my search I found freeware video editing software written and maintained by Avery Lee called VirtualDub. The software has an enormous library of filters available on the internet, all written by the user community of this software. I have found some filters that have worked well for me in enhancing the live view of both deep sky and solar system objects. In this report I will provide a very brief tutorial on what I've done so others can try it too.

The main image processing capabilities that I am looking for are:

1. Levels (or Curves) – Provides the ability to adjust the distribution of shadows, mid-tones, and highlights in the image. Can be used to greatly enhance the contrast between the object you are observing and the background, or can be used to emphasize certain features in the image. Sometimes referred to as tone mapping or tone stretching.
2. Unsharp Mask – Enhances the edge details in the image, making otherwise invisible features visible, and making visible features really pop. Especially useful on solar, lunar, and planetary viewing.
3. Noise Reduction – Used to reduce random video noise from the camera, which tends to be amplified by use of Levels and Unsharp Mask.
4. Colour Control – Gives further fine control on colour after application of other filters. Can be in the form of individual RGB adjustments or Hue/Saturation adjustments.
5. Gradient Removal – Useful for removing vignetting or amp glow.

Setup:

Information such as user guides and other knowledge bases on VirtualDub can be found at the project website: www.virtualdub.org. The program itself is hosted at SourceForge (virtualdub.sourceforge.net), and is available in a number of different versions depending on your system. VirtualDub is for Microsoft Windows operating systems only. The current version is 1.9.11. The plug-in filters I use were written either by Avery Lee and are already included in the basic VirtualDub install, or were written by Donald Graft and can be downloaded individually from his website neuron2.net. To save time, you can simply download all the files at once from my website at karmalimbo.com/aro/virtualdub.zip.

The 1.7Mb install package is really just a zipped up folder with all the necessary files in it. You only have to uncompress the archived folder where you want it to be located, and run the executable VirtualDub.exe to start up the program. If you want to add your own filters, you simply copy the .VDF file into the "plugins" folder and it will appear in VirtualDub when you start it up.
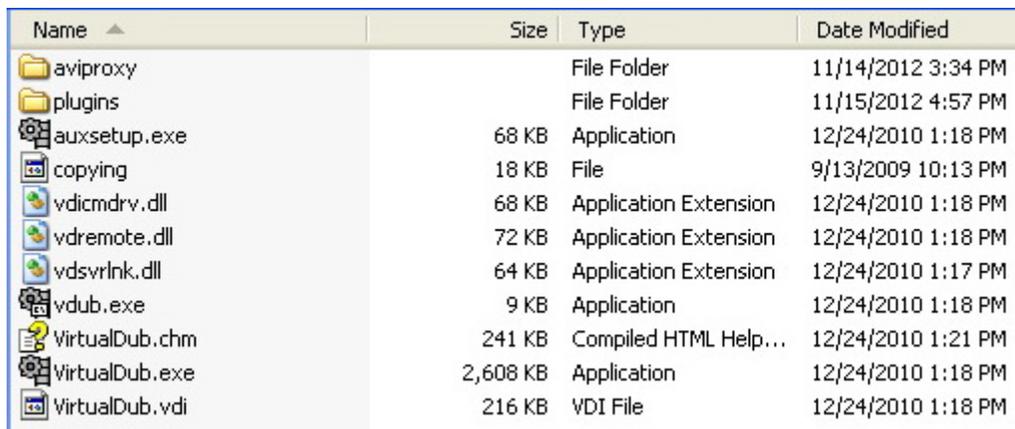
Name ▲	Size	Type	Date Modified
aviproxy		File Folder	11/14/2012 3:34 PM
plugins		File Folder	11/15/2012 4:57 PM
auxsetup.exe	68 KB	Application	12/24/2010 1:18 PM
copying	18 KB	File	9/13/2009 10:13 PM
vdicmdrv.dll	68 KB	Application Extension	12/24/2010 1:18 PM
vdremote.dll	72 KB	Application Extension	12/24/2010 1:18 PM
vdsvrlnk.dll	64 KB	Application Extension	12/24/2010 1:17 PM
vdub.exe	9 KB	Application	12/24/2010 1:18 PM
VirtualDub.chm	241 KB	Compiled HTML Help...	12/24/2010 1:21 PM
VirtualDub.exe	2,608 KB	Application	12/24/2010 1:18 PM
VirtualDub.vdi	216 KB	VDI File	12/24/2010 1:18 PM

Figure 1 VirtualDub Program Folder Contents

Getting Video Into VD:

VirtualDub is able to capture video from any device currently installed on your PC, much like you probably do now using Amcap, your NSN broadcast window, or capture software. Here are the steps you need to follow:

1. Startup VD, and under the "File" menu select "Capture AVI…" to bring up the video capture window.
2. Under the "Device" menu select the appropriate device you wish to capture from. The program will remember the last device you selected the next time you start it up. After you select your device you will be able to access your device's settings

from under the "Video" menu (look for "Video Source", "Capture pin" and "Capture filter").

3. You should now see the feed from your video device. To be able to apply filters to this stream you have to go to the "Video" menu and select "Preview". Then under the same menu select "Progressive – Both Fields" for the "Preview Acceleration". You can play with this setting, but I find the above works best.

4. You can select the video resolution and colour encoding you want by selecting "Set Custom Format…" from the "Video" menu. You can select from a list of standard resolutions and encoding standards, or enter your own custom resolution. If your capture device does not support the settings you've selected the software will tell you so. The most common resolution is 640x480 or 720x480, and the colour encoding is most often UYVY.
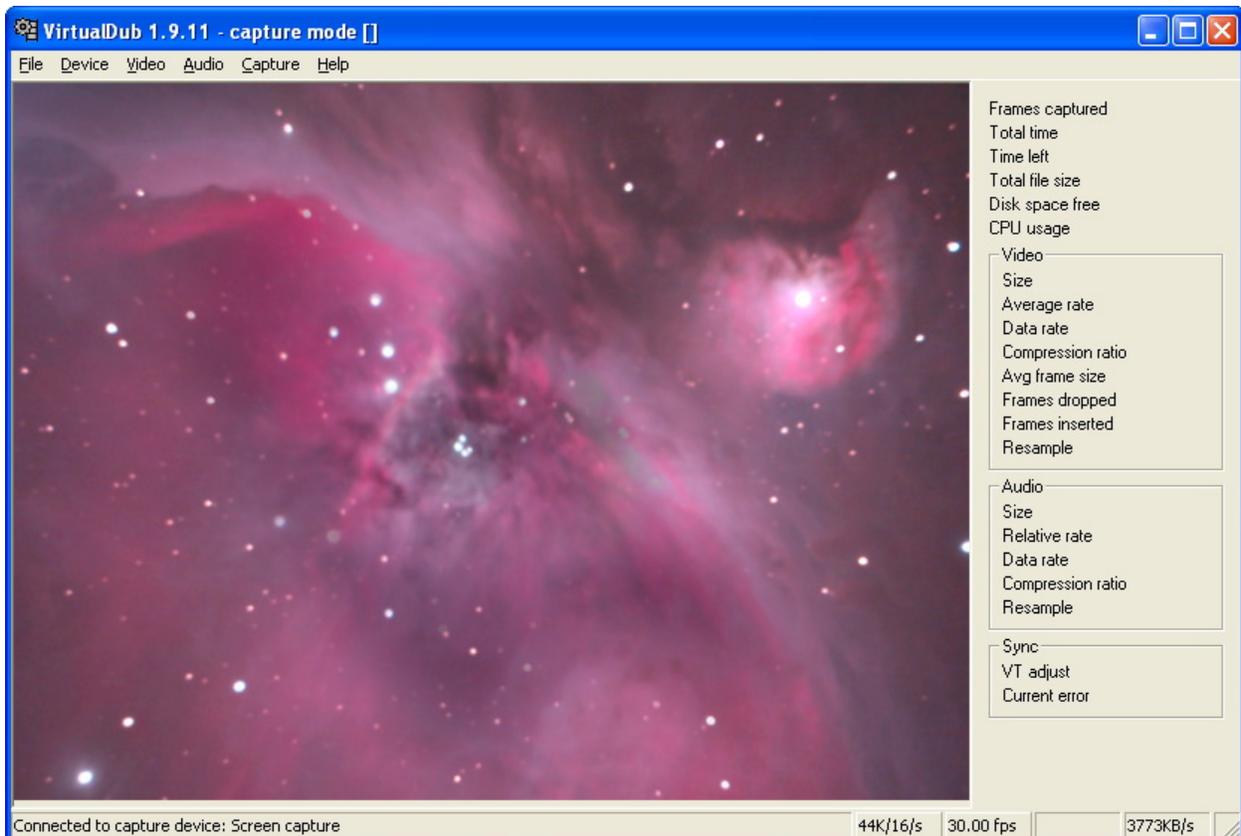

Figure 2 Appearance of "Capture AVI..." window

5. If you have a camera that does not provide video like a typical capture device or webcam (ie. using WDM or DirectShow), you can use the screen capture option. Under the "Device" menu select "Screen Capture". Then go to "Set Custom Format…" under the "Video" menu and pick the screen capture size you want, and

colour encoding (normally "32-bit ARGB"). Finally go to "Source" under the "Video" menu to check the screen capture settings. I use the following settings:

    a. Select "Use fixed offset", with X and Y values set to a location on the screen where my camera's image stream is being displayed

    b. For "Panning area", I use "entire desktop"

    c. Check "Capture mouse pointer image"

    d. Un-check "Use OpenGL hardware acceleration". You can try to have this set to on, but I haven't had any luck with it yet so I leave it off.
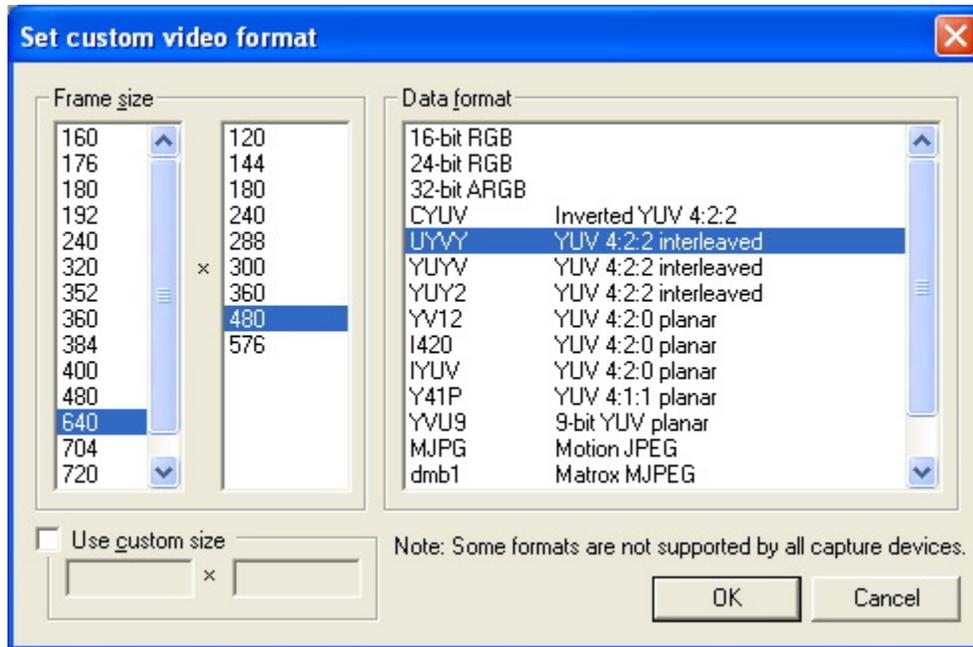
Figure 3 "Set custom video format" window

Applying Filters:

Now that you have your live video being displayed in VD, you can start playing with filters. To help you in understanding what is going on you can turn on a "Histogram" under the "Video" menu. The steps for applying filters are as follows:

1. Under the "Video" menu select "Filter Chain/Enable" to turn on filters.
2. Under the "Video" menu select "Filter Chain/Filter List". This will pop up your filter list window. From this window you can add/remove filters, change filter settings, and change the order in which the filters are applied. Unfortunately, because of the way the program is coded, you do not get a preview of the video while you are making changes in the Filter List. You will have to do some trial-and-error initially on your filter settings until you get an idea for what settings work well.

3. Navigating the Filter List window is pretty straight forward. Click "Add" to add a new filter, "Delete" to delete one, "Configure" to change the settings on the filter currently selected in the list. There is a check box on the far left side that allows you to quickly turn the filter on and off without losing your settings. Note that turning all the filters off by unchecking "Filter Chain/Enable" under the "Video" menu can sometimes give you a blank screen, so use the check boxes on the Filter List instead.
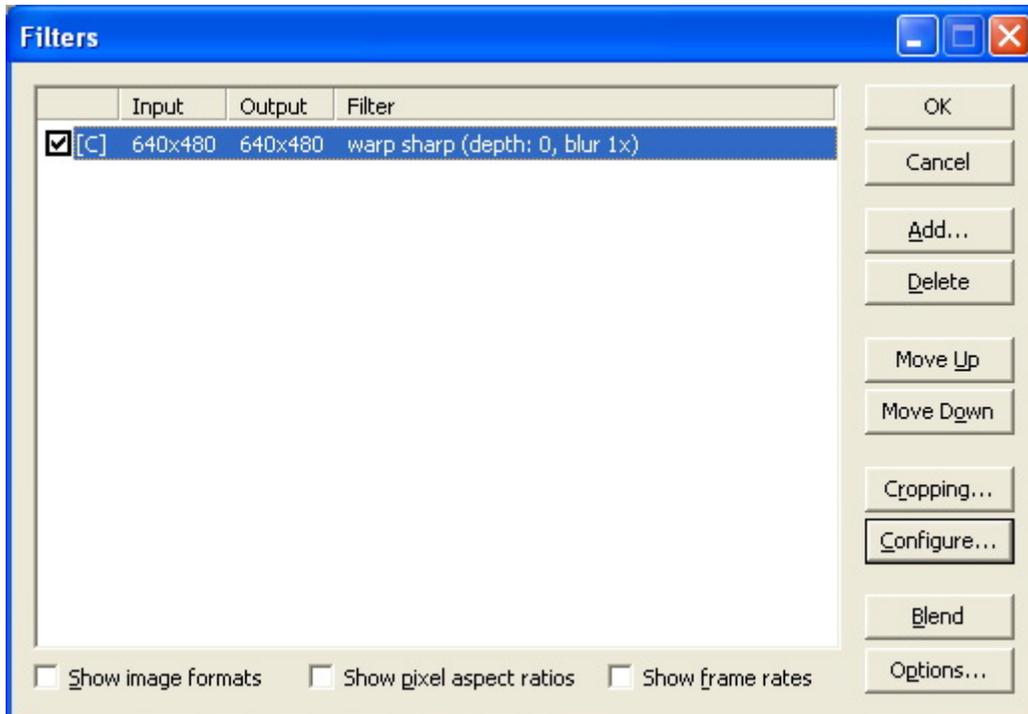
Figure 4 Filter List window

4. When you click "Add…" in the Filter List you will get a new window containing a list of all the filters currently installed in VD. The default list is long. I only use three or four out of this list, as I will describe later. Find the filter you want in the list and select it with your mouse, then click "OK". You will get a settings window for the filter you just selected. Tweak the settings as you like and click "OK".
5. When you are done adding and tweaking filters, click "OK" in the Filter List to go back to the live video with the filters now applied. To play with the filter settings to get what you want you'll have to keep going back-and-forth to the Filter List. Double-clicking a filter in the Filter List will quickly pop up that filter's settings window.

6. Filters get applied in the order they are in the Filter List, from top to bottom. You can add more than one instance of the same filter if you so desire. This can be handy for example if you need to remove amp glow and some vignetting at the same time using the "hotspot" filter.

7. Play with the filter ordering as some filters give better results before others. For example adjusting applying "unsharp mask" amplifies noise in the image so you may want to do your "curves" adjustment before it, or a smoothing filter after it.
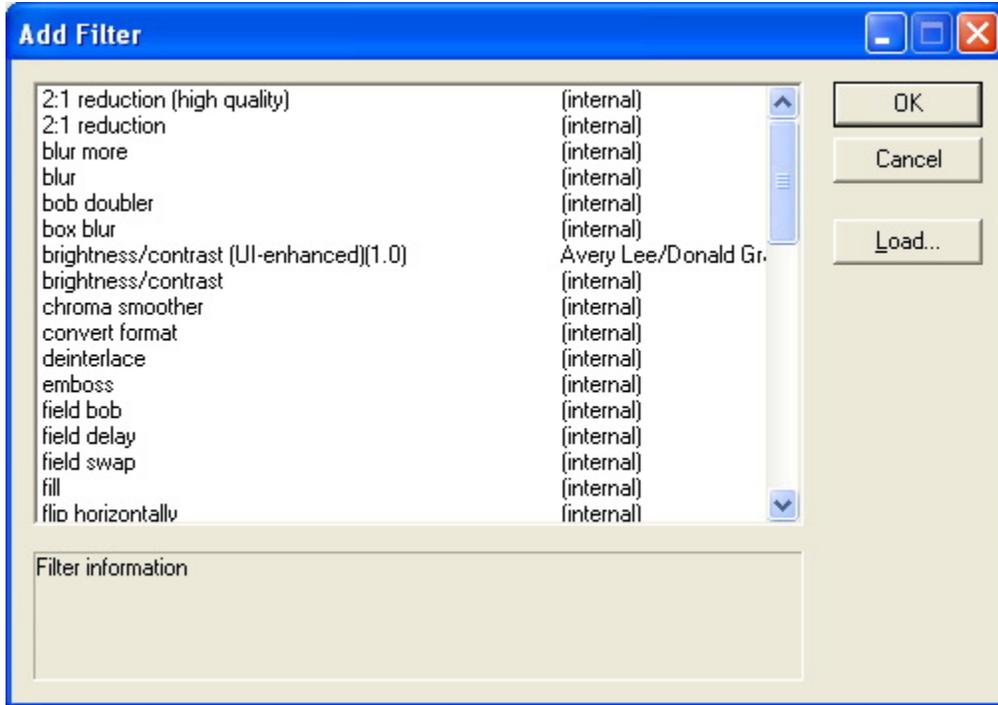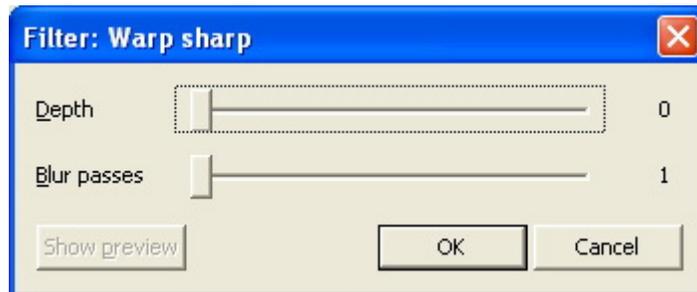

Figure 5 "Add filter" window

Figure 6 Typical filter settings window

Filter Short List:

As I mentioned earlier, I use only a small number of filters out of a long list. VirtualDub has evolved into a software tool for capturing analog video and film movies to digital, so a lot of the filters are meant for cleaning up issues with 3:2 pull-down, refresh rates, temporal noise,

out of balance chroma channels, etc. etc. Below I describe just the filters I use. You are more than welcome to try any of the other filters on your own.

> brightness/contrast (Avery Lee)
A simple tool for adjusting contrast and brightness in the image, much like what your video capture device or camera controls provide. You can use this to tweak a little more darkness out of your image, in case you've run out of adjustment on your capture device.
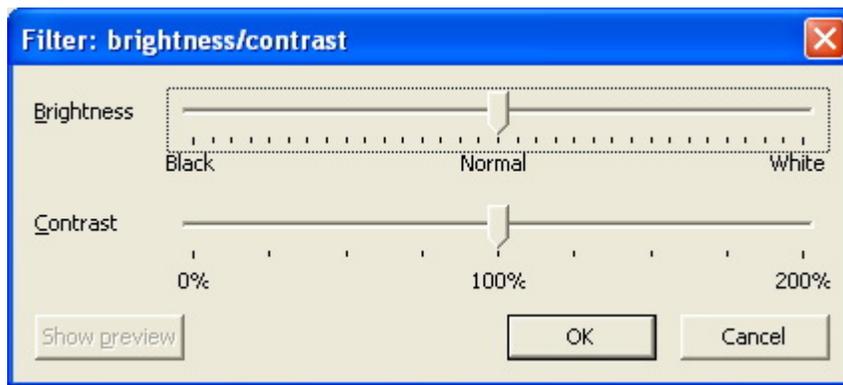

Figure 7 Brightness/Contrast filter settings window

> blur or blur more (Avery Lee)
These are very basic filters for blurring the image, either a little bit or a bunch. There are no settings for this filter, it is either on or off. Sometimes useful for smoothing very noisy feeds then sharpening after.

> graduation curves (Alexander Nagiller)
This is a very powerful filter, and is probably one you will use a lot. This filter is identical to the "curves" tool you find in most image editing software, but is also sometimes called "levels adjust" or "tone balance". The filter allows you to change how shadow, midtones, and highlights are distributed in the image. This can be used for darkening your background (adjust shadow end), bringing out detail in a faint object (adjust midtones), or brightening up dull stars or lunar images (adjust highlight end). You can use the filter to adjust brightness and contrast as well. Moving the whole curve upwards brightens the image, downwards darkens the image. Rotating the whole curve clockwise decreases contrast, rotating counterclockwise increases contrast. Gamma is adjusted by pulling the middle of the curve up (gamma up) or down (gamma down). By selecting "RGB + R/G/B" from the radio buttons in the lower right (default is "RGB only"), you can manipulate the curve for each colour channel separately. A great feature is that you can save your settings and load them back in at a later date.

The filter is easy to use, simply click on the curve and drag it the direction you want to go. Say for example I want midtones in the image to be brighter, then I click in the middle of the graph and drag it up, simple. You have a choice for how you want to shape your curves by using the four radio buttons on the upper righthandside. The bottom-most button is the traditional 3-point style, 2nd from bottom is multipoint smoothed, 3rd from bottom is multipoint straightline, and the topmost button is a funky sawtooth mode for wacky looking effects. I normally just use 3-point or multi-point smooth. There is a very thorough tutorial on using this filter in the "plugin_extrainfo" directory.
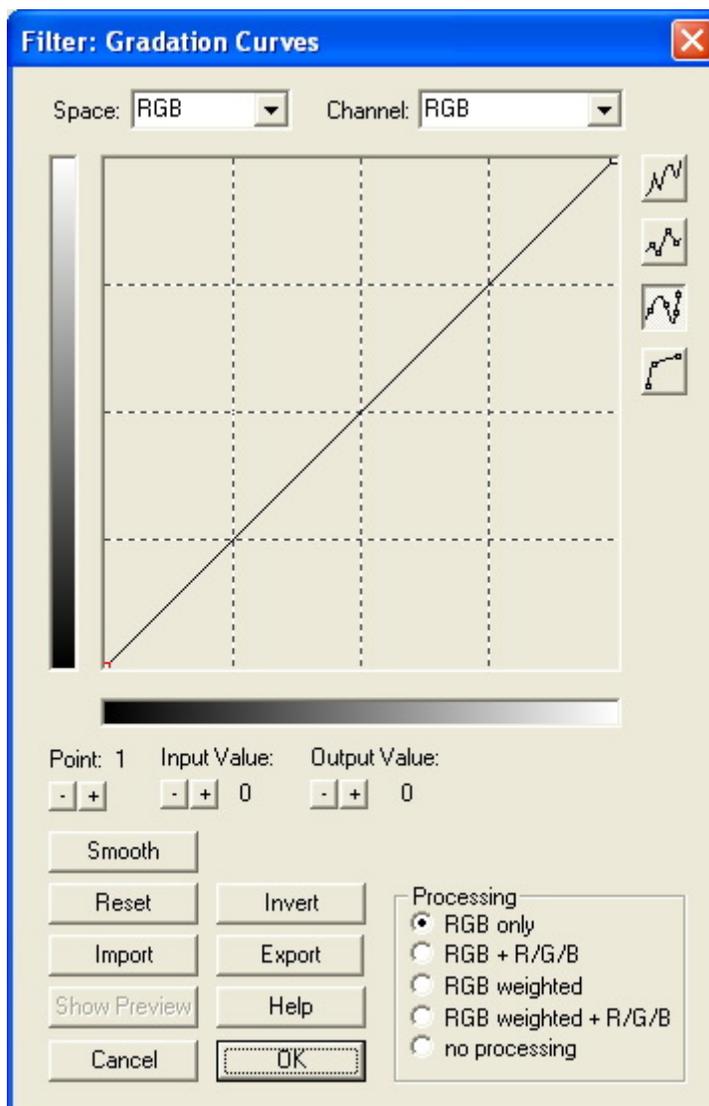

Figure 8 Graduation Curves filter settings window

> hotspot 1.0 (Donald Graft)

This filter was written originally for getting rid of vignetting, but I was able to work with the filter's author to modify it for amp glow removal as well. The filter uses a grayscale mask that you create in order to selectively brighten or darken an area in the image. The mask is in the form of a BMP file located in the "plugins" folder or elsewhere on your PC. I have created a couple of masks to get you started. Note that if your mask is not the same resolution as your video stream, this filter tosses an error message that crashes VD. In the filter settings window there is a file browse button at the top to allow you to select your mask file. You then have a choice on how you want to darken/lighten the masked area: by scaling using a multiplier, or by shifting using an offset (adder). I find for removing amp glow the Additive parameter works best. The check box labeled "invert" in the lower left tells the filter if you want to make the masked area brighter (not checked) or darker (checked).
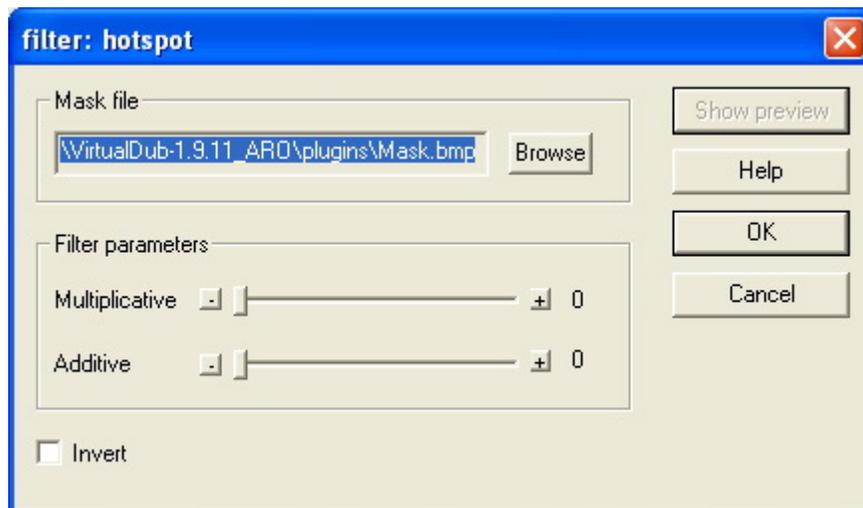

Figure 9 Hotspot filter settings window

> hue/saturation/intensity 1.2 (Donald Graft)

This filter allows you to fine tune the colour in your image. I use it when broadcasting lunar and planetary images from my Toshiba or Imaging Source cameras as they don't have a saturation slider in their control software. I especially like this filter because you can select which colour channels you apply the change to, very handy for subduing warm pixels but keeping your nebulae nice and red.
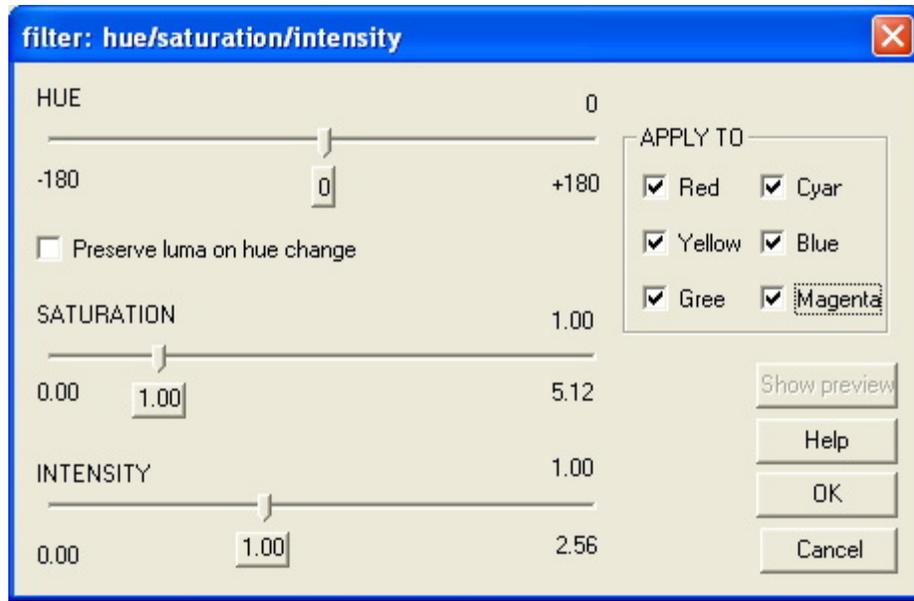
Figure 10 Hue/Saturation/Intensity filter settings window

> levels (Avery Lee)

This is a simpler version of the "curves" filter written by the author of VD. If you don't want to bother with the more complex "curves" filter than you can do your adjustment of shadows/midtones/highlights with this filter.
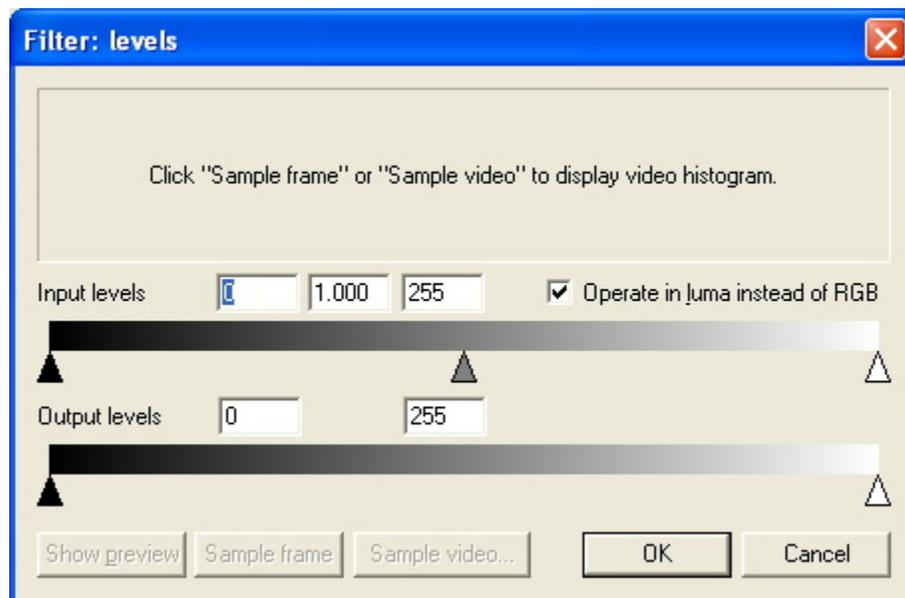

Figure 11 Levels filter settings window

> msharpen 1.2.1 (Donald Graft/Andreas Ludwig)

This filter is designed to sharpen the image only in the area of edge detail. The filter has two main controls: "strength" to adjust how much sharpening is applied, and "threshold" that determines how strong an edge detail is included in the sharpening (a lower threshold sharpens more of the image). If interested you can see what the filter is doing by clicking the "show internal" check box. The "blur method" setting allows you to very how the edge detection process is performed. "Cross" is less accurate but fast, "3x3" is fairly accurate but a little slower, and "Radius 1" is the most accurate but is the slowest. In our case, since we are often only getting refreshes every minute or more, we can use the best but slowest blurring method (Radius 1).
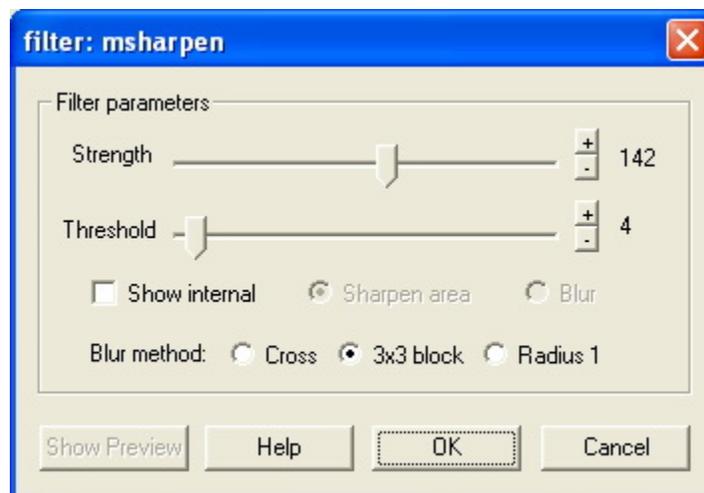

Figure 12 Msharpen filter settings window

> red/green/blue/sat/contrast 0.0 (Donald Graft/Yaroslav Pidstryhach)

This is yet another filter for adjusting the colour in your image. This one allows you to adjust the RGB channels similar to the manual white balance controls in your camera control software. The advantage here is you can make more precise changes to the RGB values than in some of the camera control software.
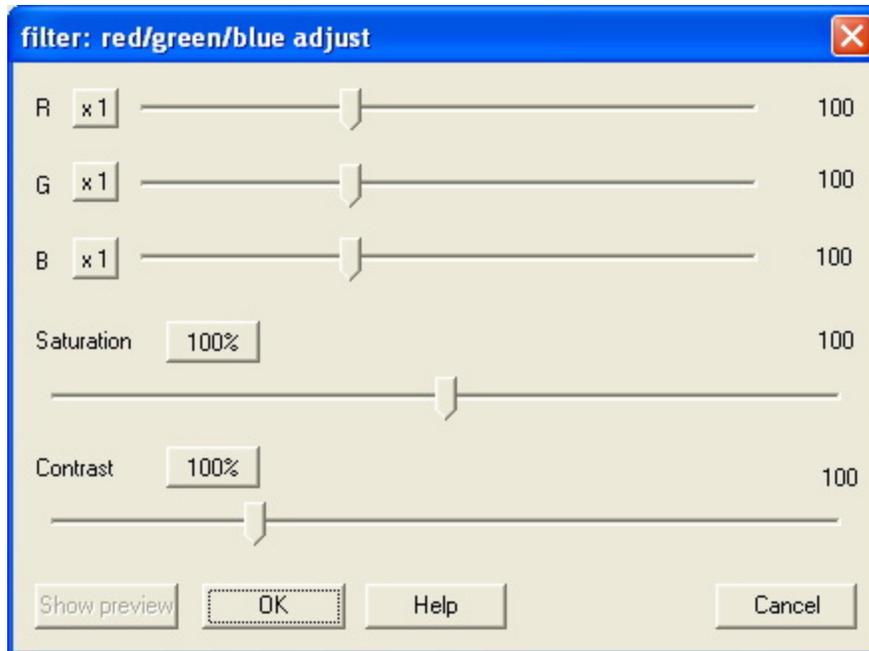
Figure 13 Red/Green/Blue/Sat/Contrast filter settings window

> **smart smoother 1.1 (Donald Graft)**
Smart smoother is one of the better noise removal filters I've been able to find. Even still I am not overly impressed by what it can do for our type of image. It is fairly easy to use, with just two settings: "diameter" sets the diameter of pixels within which to average (bigger number blurs each pixel over a wider area), and "threshold" is really a misnamed blur strength (larger number blurs more).

Figure 14 Smart Smoother filter settings window

> smoother (Avery Lee)

This is a very basic smoothing filter that works pretty well on images that are all-over noisy. Settings consist of a single slider for strength. I'm not sure if the check box for "enable noise prefilter" does anything.
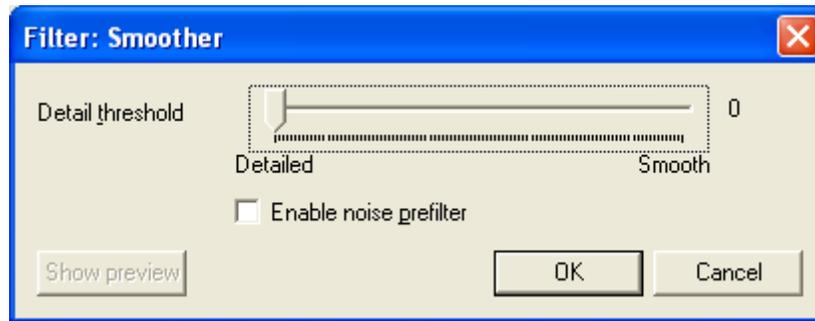

Figure 15 Smoother filter settings window

> unsharp mask 1.3 (Donald Graft)

This is pretty much your typical unsharp mask filter like you would find in your photo editing software. It is used to sharpen and enhance features in the image, but it often does so along with enhancing noise in the image too. I like to use this filter when live viewing the Moon as it really enhances fine details. The three main settings for this filter are: "diameter" which determines the size of the neighborhood around a pixel over which a neighborhood average is determined, "strength" determines how much sharpening to apply, and "threshold" defines how much different a pixel needs to be from its neighborhood average before it is included in the sharpening. A large diameter setting will enhance only larger features, a small diameter enhances smaller features. A large threshold enhances only very well defined features (strong edges), and a small threshold enhances more subtle details including noise. This filter allows you to mask off the outside edges of your image in case you have borders and things that you don't want sharpened. You probably won't need to touch these.
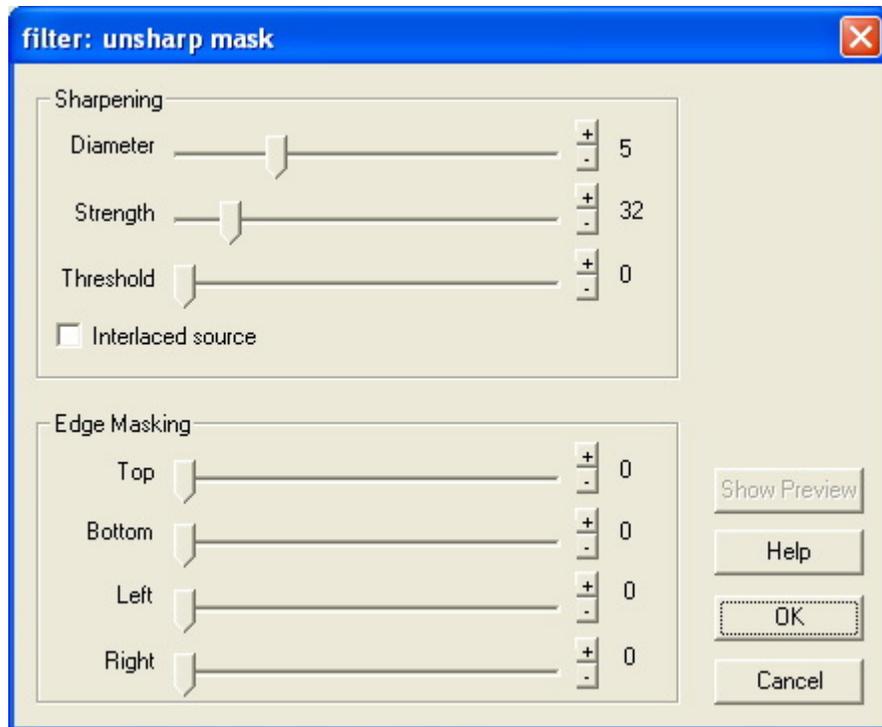
Figure 16 Unsharp Mask filter settings window

> **warp sharp (Avery Lee)**

I was very pleasantly surprised when I first tried this filter. It is a variation of a standard sharpen filter, except that it is designed to smooth the image towards detected edges. This has the effect of tightening up the image around details. I especially love the way it tightens up stars, making them almost pin points and eliminating the "panda eyes" that you get from using ALC on the Mallincam. It also tightens up warm pixels to the point where they are almost not visible. There are only two settings for this filter: "depth" which is essentially how strong a sharpening you want, and "blur passes" which adjusts how far away from the edge detail the image gets warped/blurred. I usually leave the blur passes at 1 as more seems to distort the image too much. For a depth I usually don't go much above 200. More than that and the image starts to look a bit cartoonish. Anyway try this one out for sure, on DSO's and on the Moon.
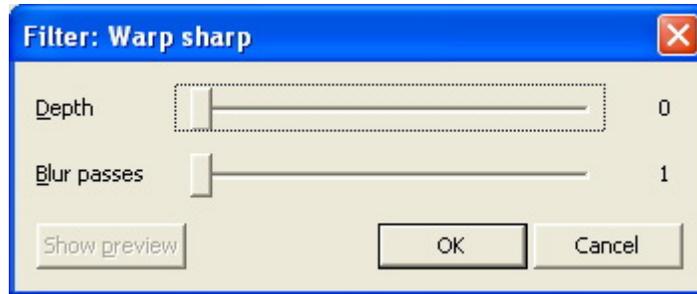
Figure 17 Warp Sharp filter settings window

Some Sample Images:

I've listed a fair number of different filters above, some of which do things similar to others. To give you an idea of what you can achieve, I've put together a couple of examples below. Each example shows a single frame captured from one of my cameras, and the modified frame after application of the listed filters. Note the "hotspot" filter is often used 2x: once for intense spot in the corner and once for the general amp glow.

Sample Batch #1

hotspot (1.0)
hotspot (1.0)
warp sharp (depth: 152, blur 1x)
gradation curves (mode: RGB only)
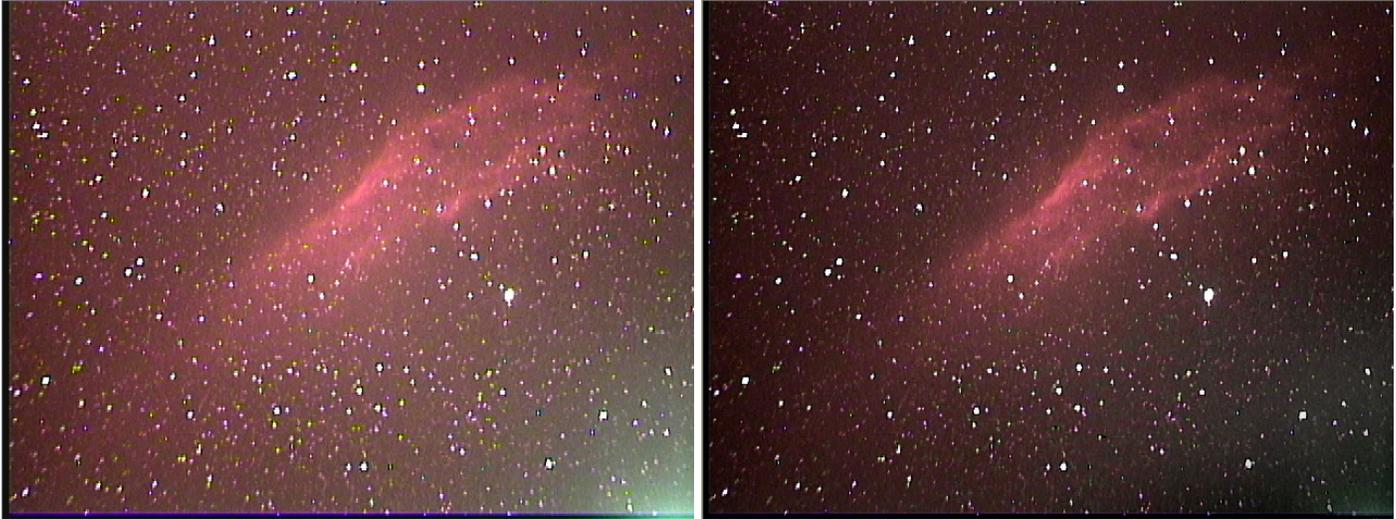msharpen (1.2.1) (str 64, thr 6, out sharp, blur block)

M16 "Eagle Nebula", MCX AGC4, 120sec INT, VRC8 f/3.5

Sample Batch #2

```
warp sharp (depth: 167, blur 1x)
hotspot (1.0)
hotspot (1.0)
gradation curves (mode: RGB only)
hue/saturation/intensity (1.2) (hue 0, sat 0.69, inten 1.00, rgbycm)
hue/saturation/intensity (1.2) (hue 0, sat 0.57, inten 1.00, gbyc)
```

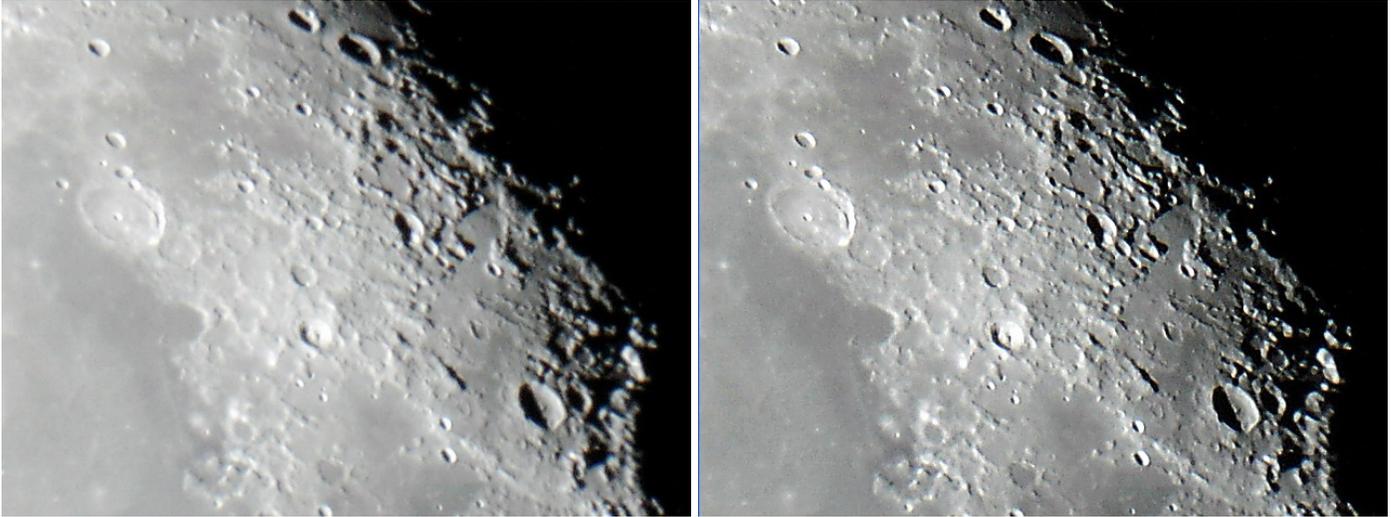NGC 1499 "California Nebula", MCX AGC4, 240sec INT, 107mm lens f/2.2

IC 1848 "Soul Nebula", MCX AGC4, 180sec INT, 107mm lens f/2.2

warp sharp (depth: 93, blur 1x)
unsharp mask (1.3) (diam 5, str 52, thr 2, clip 0 0 0 0, inter no)
gradation curves (mode: RGB only)

Moon, Toshiba IK-WB11A, 50ms, 8" LX10 f/10

Moon, Toshiba IK-WB11A, 50ms, 8" LX10 f/10

Sample Batch #4

hotspot (1.0)
hotspot (1.0)
smart smoother (1.1) (diam 5, str 70, inter no)
gradation curves (mode: RGB only)

M51 "Whirlpool Galaxy", MCX AGC4, 120sec INT, 8" LX10 f/6

Sample Batch #5

hotspot (1.0)
hotspot (1.0)
gradation curves (mode: RGB + R/G/B)
HSV adjust (h+0°, s·54%, v+0%)
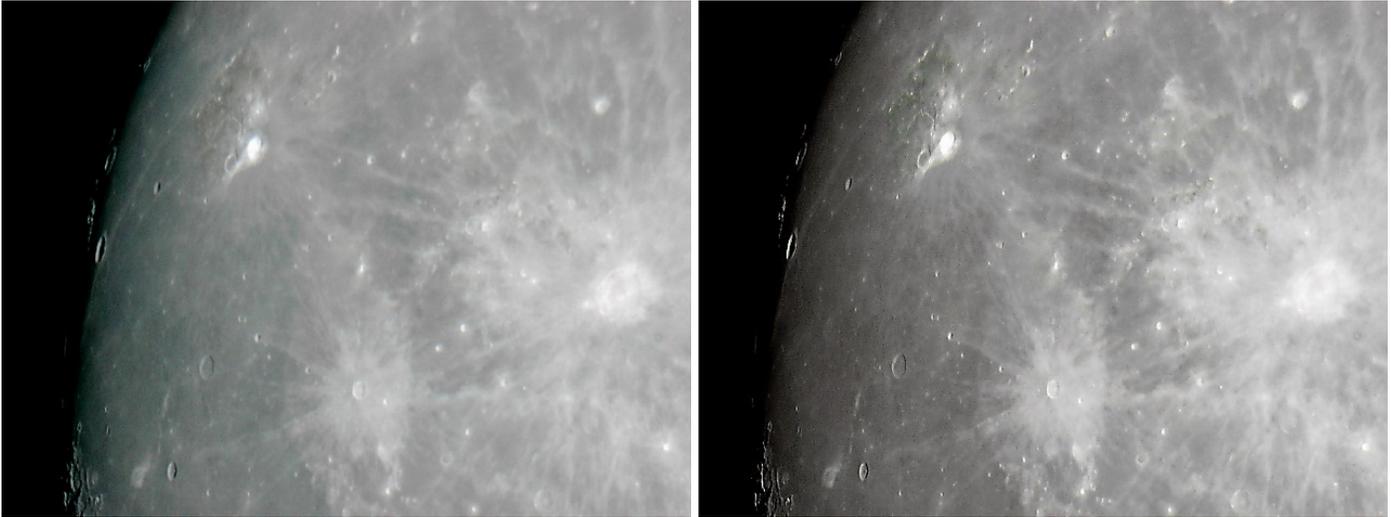warp sharp (depth: 155, blur 1x)

M31 "Andromeda Galaxy", MCX AGC4, 160sec INT, 107mm lens f/2.2

Sample Batch #6

```
warp sharp (depth: 182, blur 1x)
gradation curves (mode: RGB only)
unsharp mask (1.3) (diam 3, str 70, thr 4, clip 0 0 0 0, inter no)
hue/saturation/intensity (1.2) (hue 0, sat 1.38, inten 1.00, ry)
hue/saturation/intensity (1.2) (hue -132, sat 0.42, inten 1.00, gbc)
```

Moon, Toshiba IK-WB11A, 67ms, 8" LX10 f/10

Sample Batch #7

```
hue/saturation/intensity (1.2) (hue 0, sat 3.59, inten 1.00, rgbycm)
gradation curves (mode: RGB only)
warp sharp (depth: 42, blur 1x)
unsharp mask (1.3) (diam 3, str 64, thr 2, clip 0 0 0 0, inter no)
```

Moon, Imaging Source DBK51, 2ms, minimum gain, WO66 f/5.9

Getting Video Out Of VD:

So now that you have a nicely sharpened and tone balanced video stream, wouldn't it be nice to show the rest of the world? The whole purpose of this activity is to present sharper, cleaner, more detailed live astronomy images to an audience. If you are doing public outreach you can simply show everyone your VD preview window, but if you want to show it on NSN you have one more hoop to jump through. NSN needs to be fed a video stream from a recognized device, which VD is not. Maybe someday there will be a virtual webcam output from VD, but for now we'll have to use an existing product like WebcamMax or ManyCam. Simply select your virtual webcam software as the video device in NSN, then in your virtual webcam software select "screen capture/specific area". Centre the captured area over your VD preview window and you're done. I personally use WebcamMax as I like to annotate and sketch over top of my broadcast to help explain things.

Well, that's it. I hope this little tutorial has been helpful. I encourage you to experiment with the different filters as the best settings to use will vary from night to night, and from target to target. If you have any questions, please feel free to contact me.

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