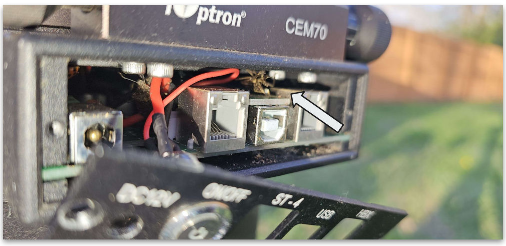
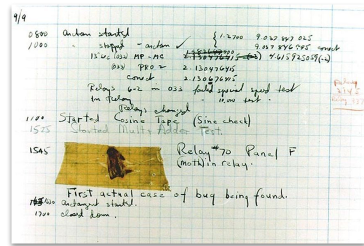
Astrophotography:
Bringing nebula to light with AI

Lorin Bales

Lessons Learned in Debugging





Remember…

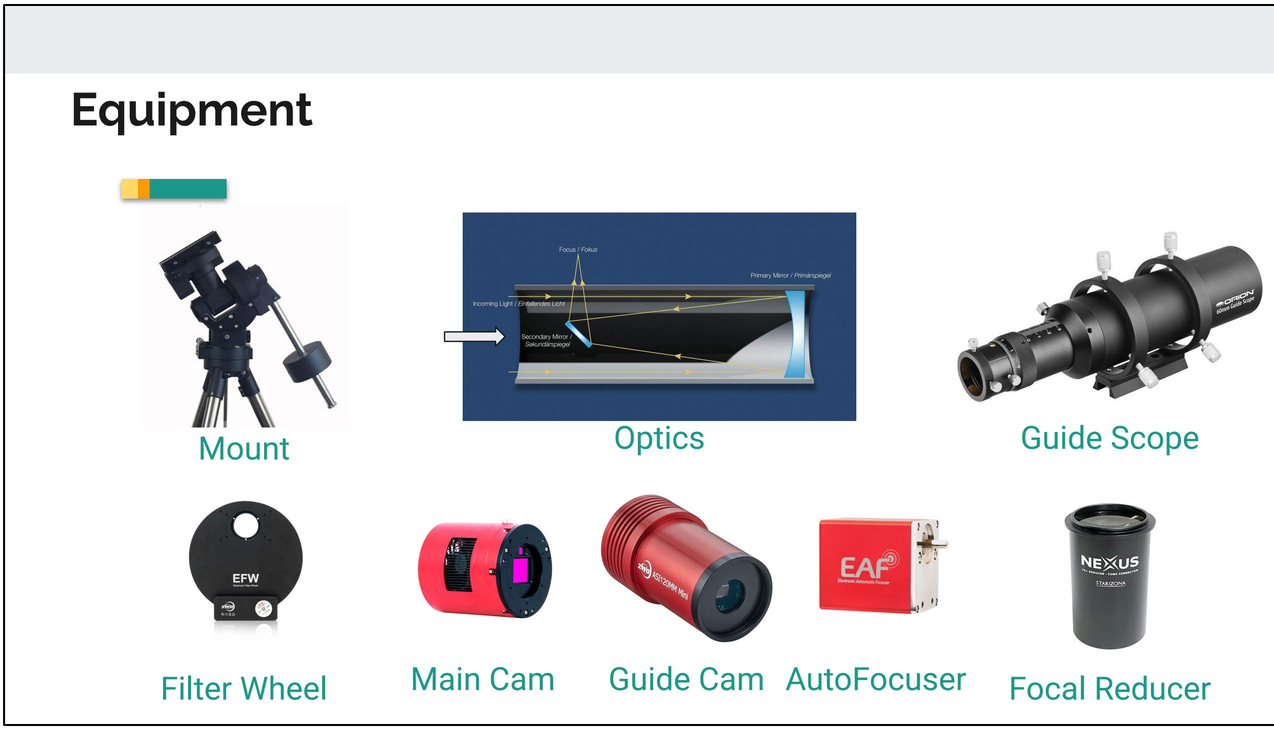
- It’s up to us to make things happen
- Hard work is what determines the outcome
- Accepting change quickly
- When struggling, we must stay resilient

"First actual case of bug being found," according to Harvard, 1945. The engineers who found the moth were the first to literally "debug" a machine.

There are some universal lessons in astrophotography. For several weeks in the Spring, I couldn’t connect to my mount. I evaluated the firmware, software, OS, and cabling. I finally ordered a new chip for the mount, hoping a firmware update would help only to find that I had a literal bug in my mount. Remember, it’s up to make things to happen, hard work determines the outcome, acceptance is key to staying resilient.

How to capture a nebula?

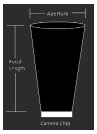
- Equipment
- Software
- Processing & AI Techniques
- Hubble Comparison

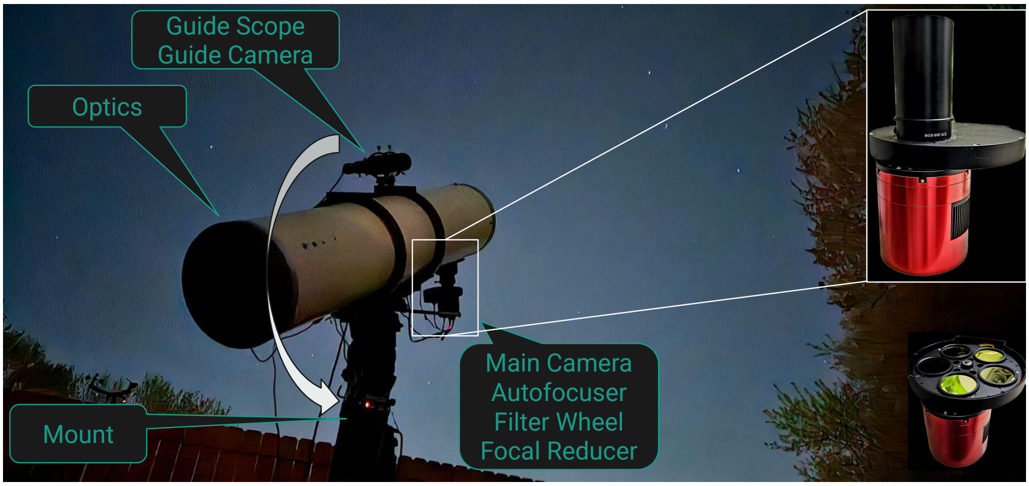


The mount tracks the stars (with the help of the guide scope), the optics captures the light, and then you capture the light with a camera. The focal reducer is about increasing the light of the capture and the filter wheel is selecting the wavelength of the light.

Let’s talk about the optics, this is newtonian optic where the light comes from the end of the tube, hits the primary, and then exits the secondary to the focal point for the sensor to capture the light.

Newtonian Optics: Parks Optical 1960’s (#601-10070)





Speaking of the optics, this is my newtonian telescope. This is the fully integration of the optics, mount and cameras.You have the guide scope on the top that interfaces with the mount to track the stars and keep the image stabilized. The light passes through the lens of the focal reducer, the filter wheel down-selects the wavelength, and then captured by a cooled camera to reduce noise.

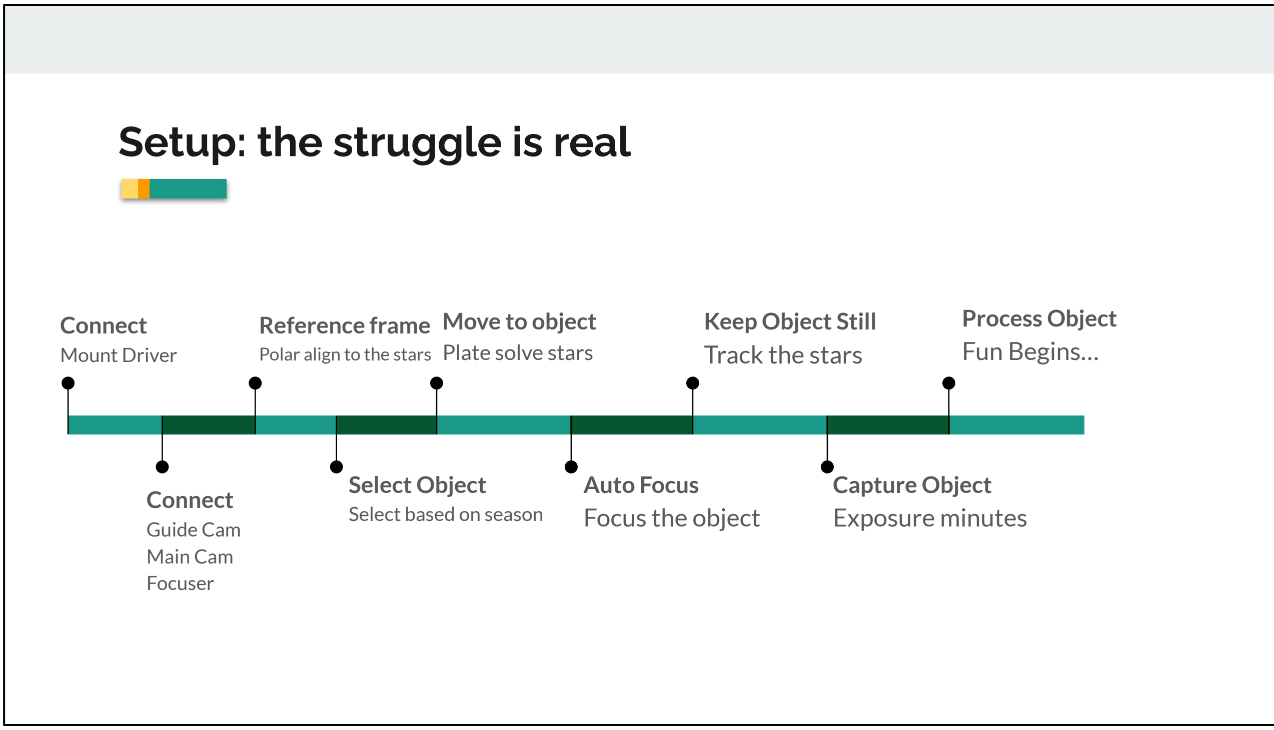
Info: My telescope is likely a kit from the 1960’s from talking with David Naillon, Parks representative. It was a dobsonian kit sold in the 1960’s before they made equatorial mounts.

From the wayback machine in 1999:
10" f/5 Superior O.T.A.

Specifications of Parks Optical 10" f/5 SUPERIOR O.T.A.:
Includes: 10" f/5 Primary Mirror, 10" Primary Mirror Cell, 2.60" Secondary Mirror, 2.60" Secondary Mirror Holder, 11 7/8" 4 Vane Spider, 2.00" Rack & Pinion Focuser, 11 7/8" ID (12 ½" OD) x 50" Fiberglass Tube (gloss white exterior, matt-black non-reflective interior), (2) End Rings, 8x50mm Finderscope with Bracket, 25mm Kellner Ocular 1.25", Collimation Tool, (2) Dust Covers,Optical Certificate and Instructions.

Software: Dependency Hell

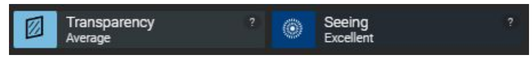
1. Mount Driver
2. Reference frame of the stars
3. Camera Driver
4. Guiding
5. Selecting Object
6. Automating Image Capture
7. Signal-to-noise ratio
8. Processing the images
9. AI Techniques



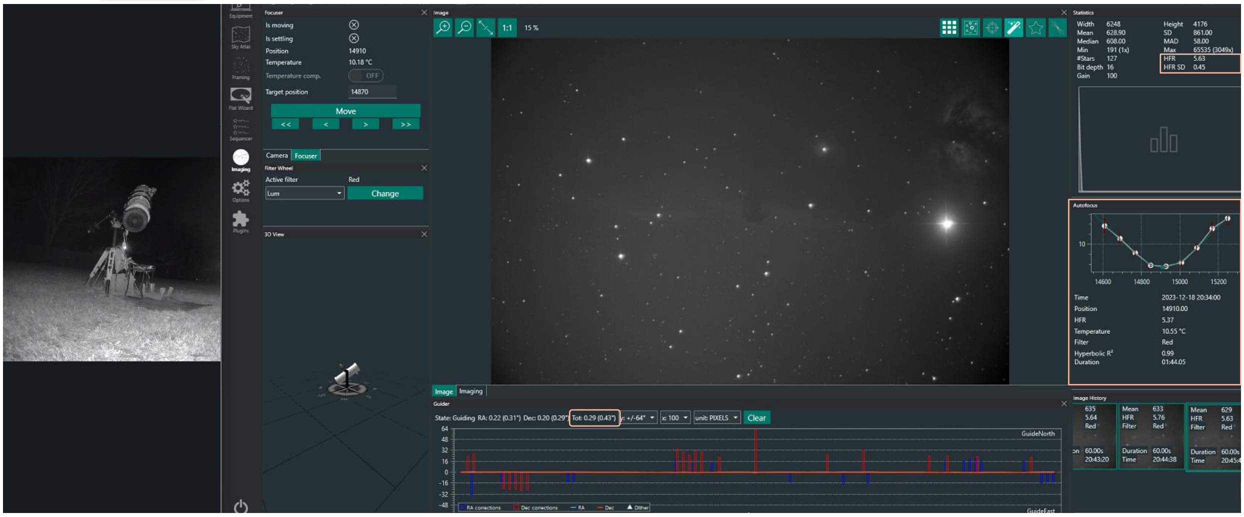
The setup is pretty smooth these days, but it can still be a struggle to have success every time, as there are things outside of our control, like weather. That said, after integrating everything, it feels a lot like the moment in E.T. when they have the antenna working…


E.T., IT'S WORKING.
IT'S WORKING!!!
yarn.co

Automation through NINA



https://astrospheric.com/

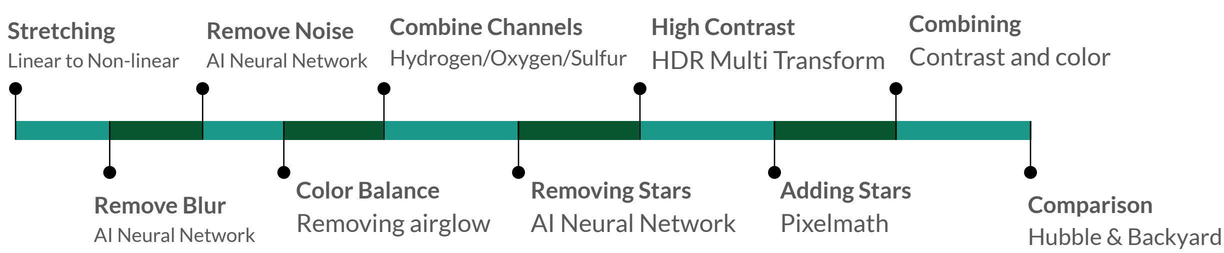


So this is a nighttime security camera on the left and NINA on the right. Nina allows for API access to the software. I want to focus on two things:

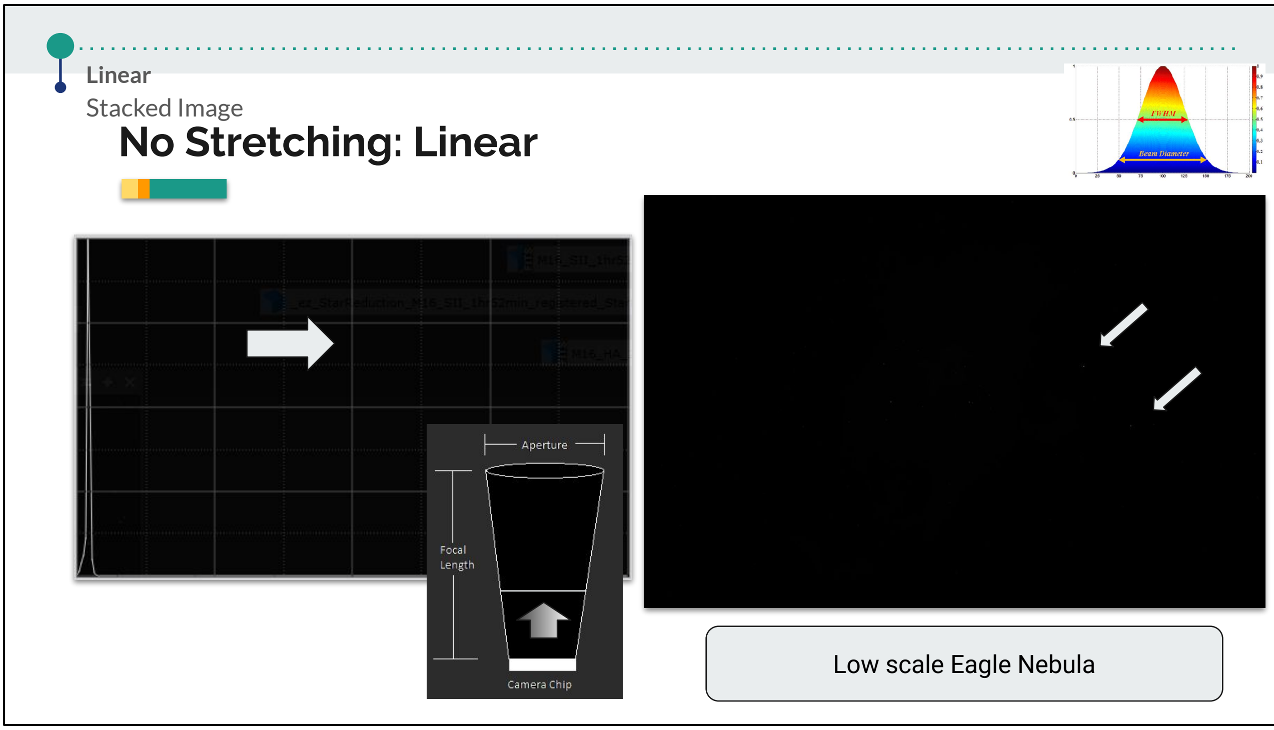
1) the hyperbolic fit autofocusing plot on the right. This process has to be successful several times all night long.

2) the mean squared error for correction in tracking. Less than 1” arcsecond is preferred.

Process Object



This is the processing steps and will be shown at the top of each slide

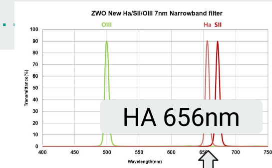


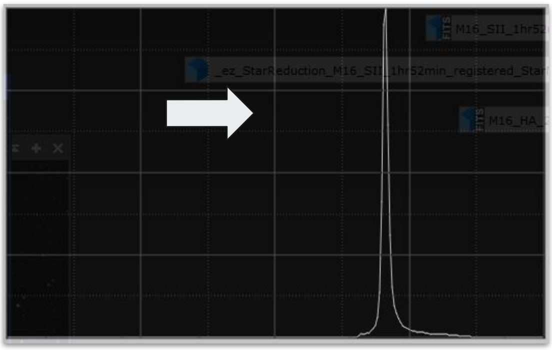
So after hours of capturing light with NINA, we have the picture on the right. The two arrows indicate the two stars in the image. The first thing we're going to do is change the scale, so if you want to think of it like a bucket of light, we want to change the scale of the image from linear to non-linear. So we're going to move the

Linear to Non-Linear

Stretching

Stretching: Linear to Non-Linear

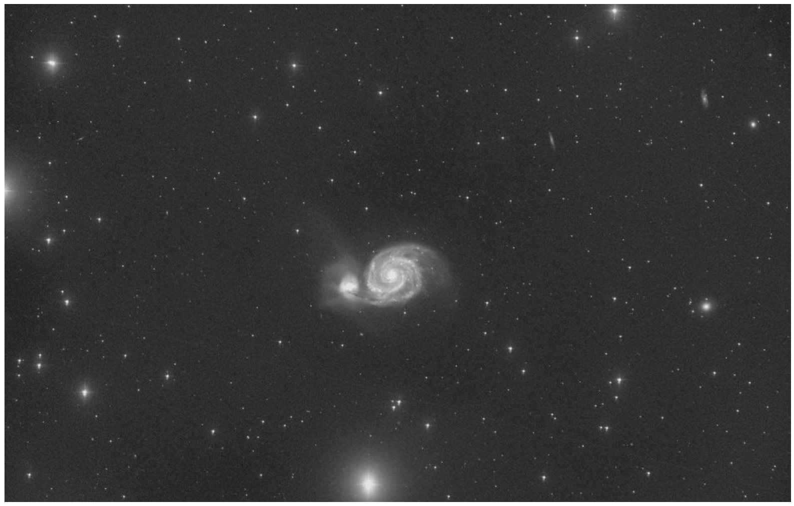




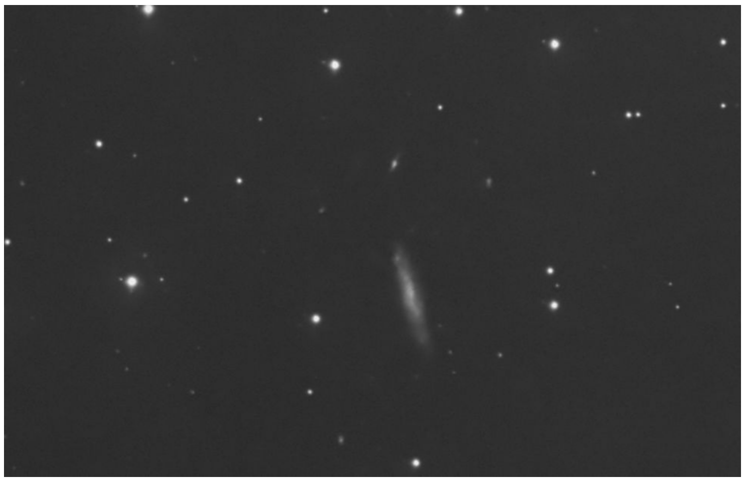
Increase scale Eagle Nebula

AI: Blur Xterminator

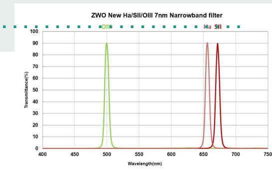
Remove Blur

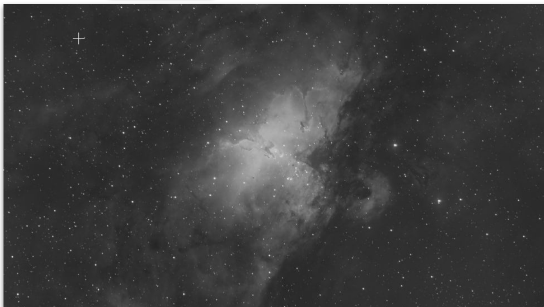


Remove Noise



Combining Channels



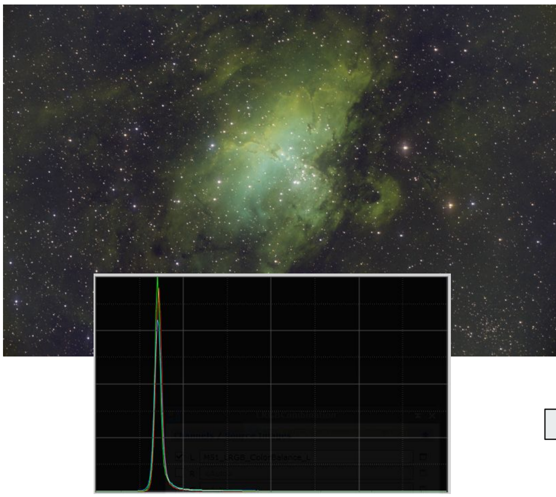


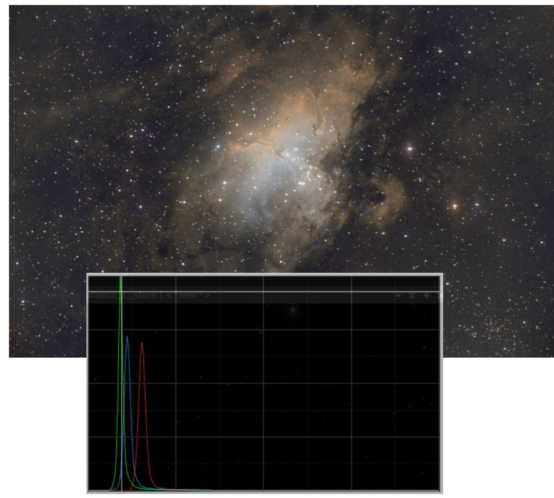
Eagle Nebula in Hydrogen Emission Line

Eagle Nebula in Sulfur

Eagle Nebula in Oxygen

Color Balance: Remove airglow



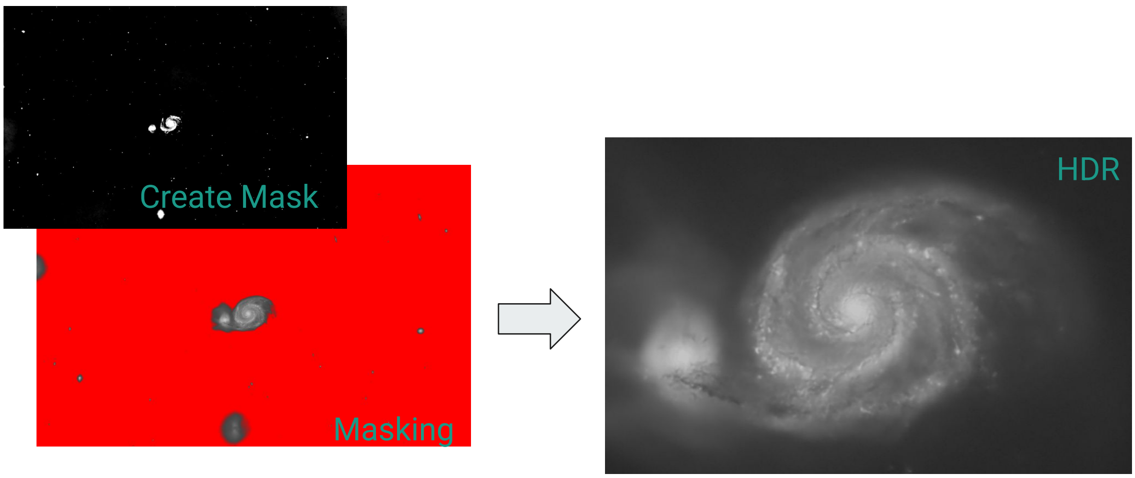


AI: [Star Xterminator]

Remove stars to focus on object

Neural network architecture trained on data from the James Webb and Hubble space telescopes

Increasing Contrast

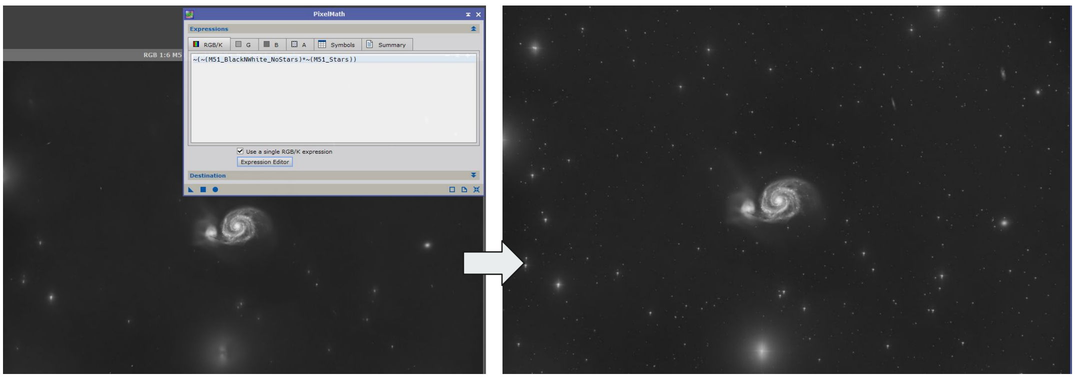


The key to increasing contrast is to utilize the Lumiance monochrome image to apply tone mapping, contrast adjustment and noise reduction through HDR or High Dynamic Range Multi Transform. The masking allows selection of the object and not increasing the detail in the background (where there is typically significant noise).

Transformations: The multi-transform process applies several transformations in sequence, each tailored to address specific issues in the image:

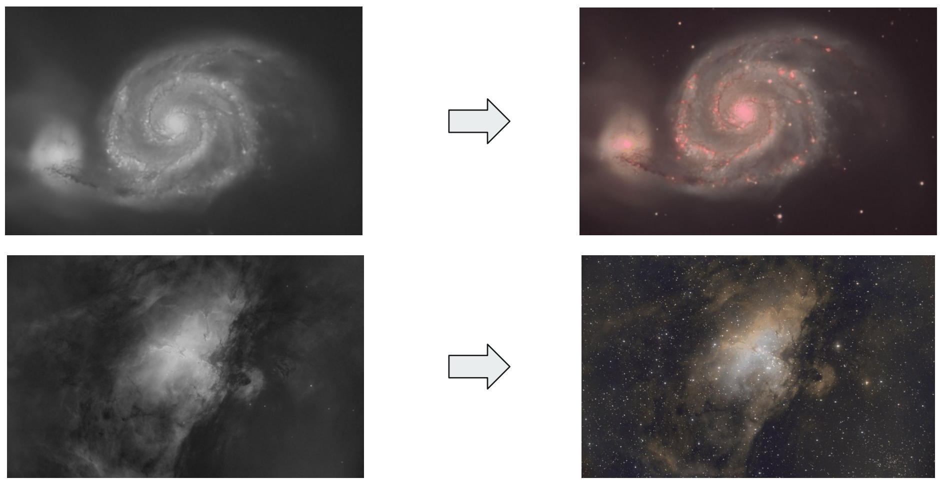
* Tone mapping: Adjusts the overall brightness and contrast of the image to make it more visually appealing
* Contrast adjustment: Increases or decreases the contrast between different parts of the image to create a more natural look.
* Noise reduction: Removes unwanted noise or artifacts from the image.

Adding the stars back



Pixel math allows us to add back the star mask that we removed earlier with the AI technique

Bringing out the details in color



Now we want to add the color to the high contrast stared image. We do this via Luminance Recombination, we add the luminance to the RGB image.

Eagle Nebula

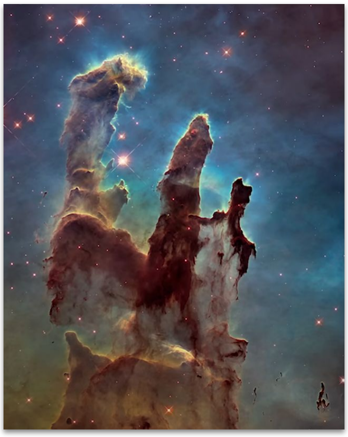
Discovered in 1745

1-2 Million years old

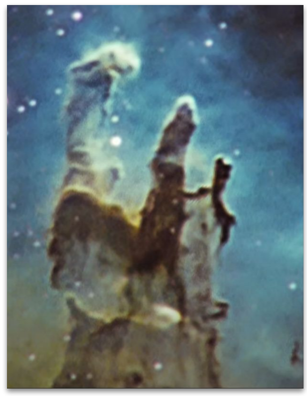
5700 light years away

Here's the final product. The eagle nebula was discovered in 1745, is about 1-2 million years old, and is 5700 light years away. And now for the comparison to Hubble…

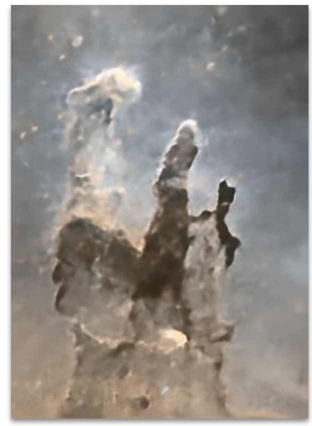
Comparison



Hubble

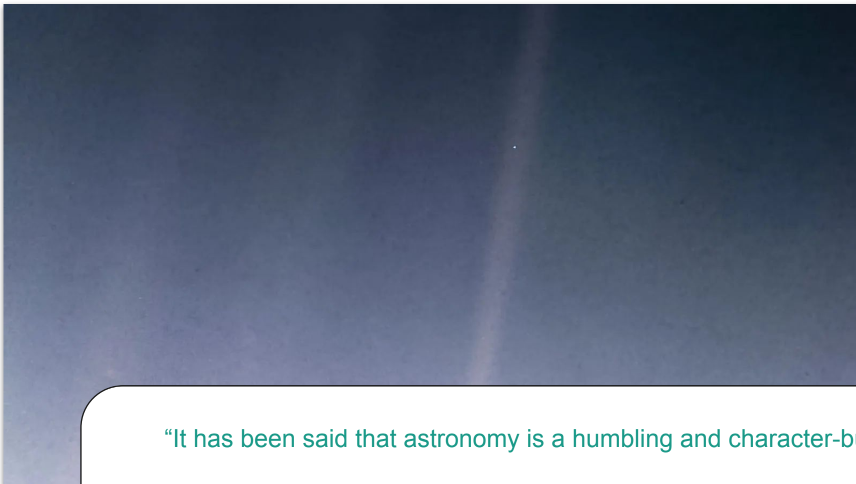


[Trevor's Backyard]



My Backyard

You have hubble on the left, a well-known content creator Trevor in the center, and my image on the right.



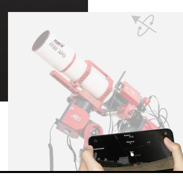
“It has been said that astronomy is a humbling and character-building experience.

There is perhaps no better demonstration of the folly of human conceits than this distant image of our tiny world. To me, it underscores our responsibility to deal more kindly with one another, and to preserve and cherish the pale blue dot, the only home we've ever known.”
Carl Sagan

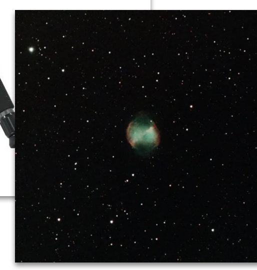
Backup

How can you get into the hobby?

~$5000



$499.00



S-Curve Adjustment