

Drizzle Your Way to Beautiful Images

Part I – Introduction and Image Capture

Using the Envisage Software with
Drizzle technology to enhance
And improve your DSI images



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Overview

When Meade Instruments release their new DSI-Pro camera in 2005, they not only provided a new camera with a monochrome CCD and higher sensitivity than the original DSI, they also re-released their Envisage software with many improvements and additions to the original suite. Among these enhancements is the ability of the software to control multiple cameras (*up to 16 DSIs and one LPI*) and the inclusion of the Drizzle technology. In this document, I will explain how Drizzle is implemented in the Envisage software and the various ways it can be used during both the capture and post-capture processing stages.

What is Drizzle?

Before getting started on how to use Drizzle with the DSI or DSI-Pro, I think it is prudent to take a moment to discuss exactly what Drizzle is. The Variable Pixel Linear Reconstruction Algorithm, better known as “Drizzle” was created for NASA to correct for undersampled images taken by the Hubble Space Telescope, provide a mechanism for enlarging these images without the normal dithering artifacts, and allow for their de-rotation. Since the software is public domain and since its features are fully relevant to most forms of digital astrophotography, it is a perfect fit for processing DSI images.

Undersampling generally occurs in astrophotography when a widefield image is taken with a combination of a CCD chip and telescope delivering < 1 pixel per arc second (*a good average is between 1 and 3 pixels per arc second*). Without going too deeply into this, the exact measurement is based on the FWHM (*Full-Width Half-Maximum*) dimension of the diffraction disk of your particular scope. According to the Richard Berry and James Burnell, “*For an image to be ‘critically sampled’, the size of a pixel must be half the diameter of the diffraction disk as defined by its FWHM dimension.*” ⁽¹⁾

However, strictly enforcing “Critical sampling” for your images with a DSI will generally result in a very small FOV, so many DSI images are captured with setups (*thru the use of focal reducers or possibly the true focal length of the scope*) that may somewhat or even greatly undersample the image. Simply put, this means that you may lose some of the finer data that you would normally pick up if more correctly sampling the image. At the same time though, you are able to image a much wider field of view.

This is where the drizzle architecture provides the greatest benefit to users of the DSI cameras and Envisage software. While other features will enable you to correct for field rotation or enlarging your image, the ability to correct for undersampling defects provides you with a means to recover a fuller resolution of the object you are imaging.

How does it work?

Now that we know what drizzle is and what it does, we can now discuss how it accomplishes this. While this information may appear tedious at best, it’s important to understand these concepts in order to best utilize this functionality. This will also provide you with the background information you will need when deciding on the specific settings you use when applying the drizzle process to your images.

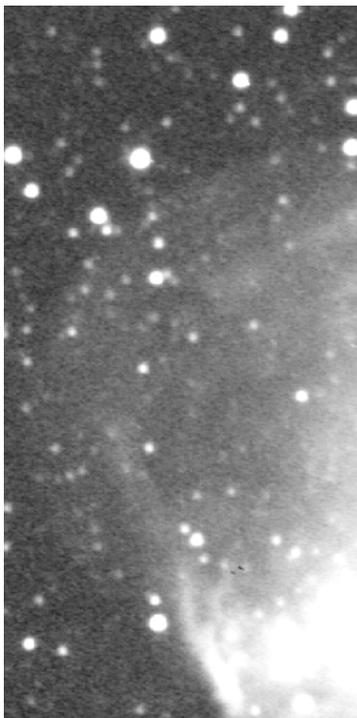
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The process of drizzling images is essentially the mapping of a set of pixels from one image (we will call it the original) to a new image (we will call it the output). The method by which these pixels are transferred uses a mathematical process to determine exactly what sub-pixel size the original pixel will cover on the output image. At the same time, the pixels are able to be placed on the output image with any rotation desired and adjusted for the desired size of the output.

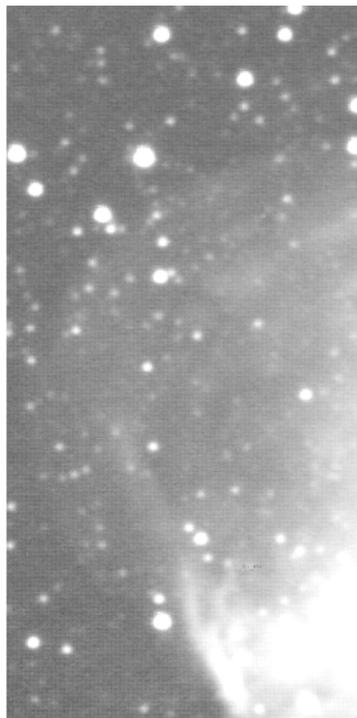
The basic idea here is that by linearly reconstructing the image applying user supplied pixel ratios (called pixel fraction in Envisage), the resultant image should be much sharper, maintain its contrast, and even deliver higher resolution detail depending on how many images are stacked. The term "Drizzle" itself comes from the fact that the resultant pixels are "dripped" onto the output "canvas". Since no attempt is made to discern between noise and signal in this process, the signal to noise ratio is maintained during this process and the full image signal is available for stacking later.

The upside is that when enough images are used at a sufficiently low pixel fraction, then all pixels should eventually be filled in when stacked. It also means that since the pixels are applied as a fraction of their original placement, they do not simply grow by a magnitude of the scale of the output image allowing for more detail to be gained during this process.

Of course, there is also a downside as well. When stacking the resultant output images, the lower the pixel fraction utilized (higher resolution), the greater the possibility of leaving tiny holes in the final image. To alleviate this, the user must stack an appropriate number of images to ensure all pixels are filled in with signal strength in line with the "dripped" pixels. This can be seen in the highly stretched image below:



3 Images Stacked / .80 Pix Fraction
Holes in image with data gaps



10 Images Stacked / .50 Pix Fraction
Pixelated, not enough images



10 Images Stacked / .80 Pix Fraction
Smoother, not pixelated

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As can be seen, the image that was drizzled at .80 with only 3 images has lots of holes showing where data is missing requiring more images to be stacked in order to use this pixel fraction. The second image shows the classic “pixel squares” that also come from not enough images for the pixel fraction. In this case, 10 images were stacked but the pixel fraction was reduced to .5. The final image uses the exact same 10 images, stacked with drizzle and a pixel fraction of .8. In this image, you can see that the entire image is much smoother, no missing gaps and no “pixel squares”. Each of these images were also increased by 1.5 times their original size.

When using drizzle to enlarge your images, ensure that the combination of the number of images to stack, the increased resolution size, and the pixel fractions are proportioned appropriately to ensure the highest quality output. In experiments, I have found that the reduction in pixel fraction by the number of images to be stacked is a good starting point. In other words, if you have 10 images, reducing the pixel fraction to .9 should work well. I have, so far, not found that pixel fractions below .5 provide any further enhancement and generally stay at or above .7 depending on the final output resolution.

A Few other Notes

Before we get started in how to use drizzle in your imaging or post-capture processing, there are a couple of other items that should be covered. First, other than simple field de-rotation, the effects of drizzle are nearly lost when used on images that are not enlarged from their original size. This is also true if you leave the resolution the same (640 x 480) and change the pixel fraction. In this situation, there is nothing to be gained by drizzle processing the image. If using drizzle for post processing your images, then it only make sense to at least somewhat expand the drizzle resolution and set a pixel fraction that will enhance your images.

Secondly, depending on the speed of your system, the resolution selected, etc, you may be better off simply processing the images post-capture with drizzle rather than using the drizzle features during capture. This is because the process of applying the drizzle algorithms to the captured image is more memory and time intensive than the standard capture and stack process and may cause unwanted delays between images. This is something that you will simply need to test on your system to discover which process works best for you.

Thirdly, remember that only the stacked image, whether during capture or in post processing, is actually saved with the drizzle transformations applied. The individual images are still saved in the native format you have selected. For instance, if you are using drizzle during the capture session and are de-rotating the image and enlarging it at the same time, the only image that will reflect these changes is the stacked image. The actual FITS files you have saved (if set to Save Every Image) will still retain their original image as directly captured. No de-rotation or enlargement is saved with the image.

De-Rotating Images with Drizzle during Image Capture

The drizzle functionality in the Envisage software can be utilized during either the capture or post-capture process. While the differences between the two usages is only slightly different, I will discuss them separately here so you can see how to use these tools in each process. In this section, I will discuss using drizzle during the

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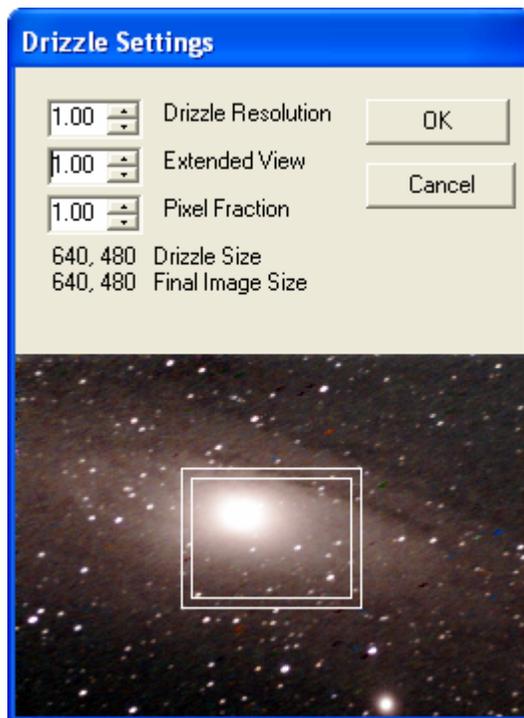
capture process and the various settings available to you along with some ideas on how to more efficiently use this technology.

The first, and probably most common uses of drizzle in the capture phase is using its built in de-rotation functionality. This is especially true for those users with Alt/Az mounts rather than equatorially mounted telescopes. For those with equatorial mounts, drizzle de-rotation also offers an advantage in that it will help remove any latent rotation due to an imperfect polar alignment.

De-rotation in Envisage is accomplished by applying the drizzle algorithms to the captured image as it is added to the stacked output based on the location of two stars selected by the user. As each image is captured, the centroid of the selected stars is determined and compared to the location of those stars in the original image. The image is then rotated and shifted as needed to map these stars to the original and any other drizzle options are also applied. The captured image is then saved to the hard disk (if Save All Images is selected) in its original format (prior to drizzle application) and the next image begins the capture process.

To use drizzle to de-rotate your images, ensure that you have setup your camera, focused your telescope, and determined the length of your exposures as you normally would. Perform the following procedures:

- 1) Ensure that you have selected drizzle from the Image Process drop down list as seen on page 5.
- 2) For this example, we will not be utilizing any other drizzle features, so you will want to check the drizzle options to ensure all the default settings are selected. To check these settings, click the blue Settings Button to display the Drizzle Settings dialogue as seen below:

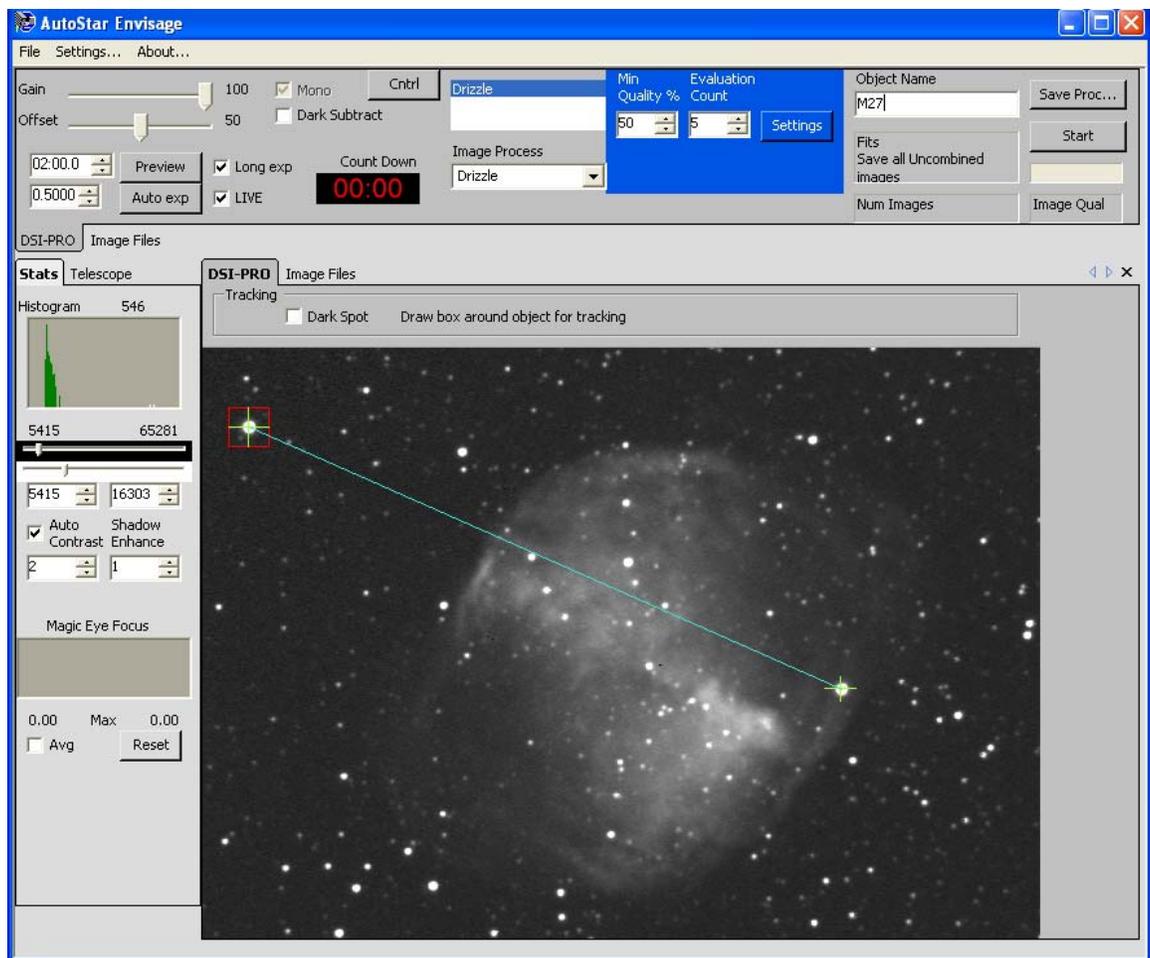


Note: the default settings are all 1.00 and 640 x 480

More will be discussed on the use of these settings later in the document.

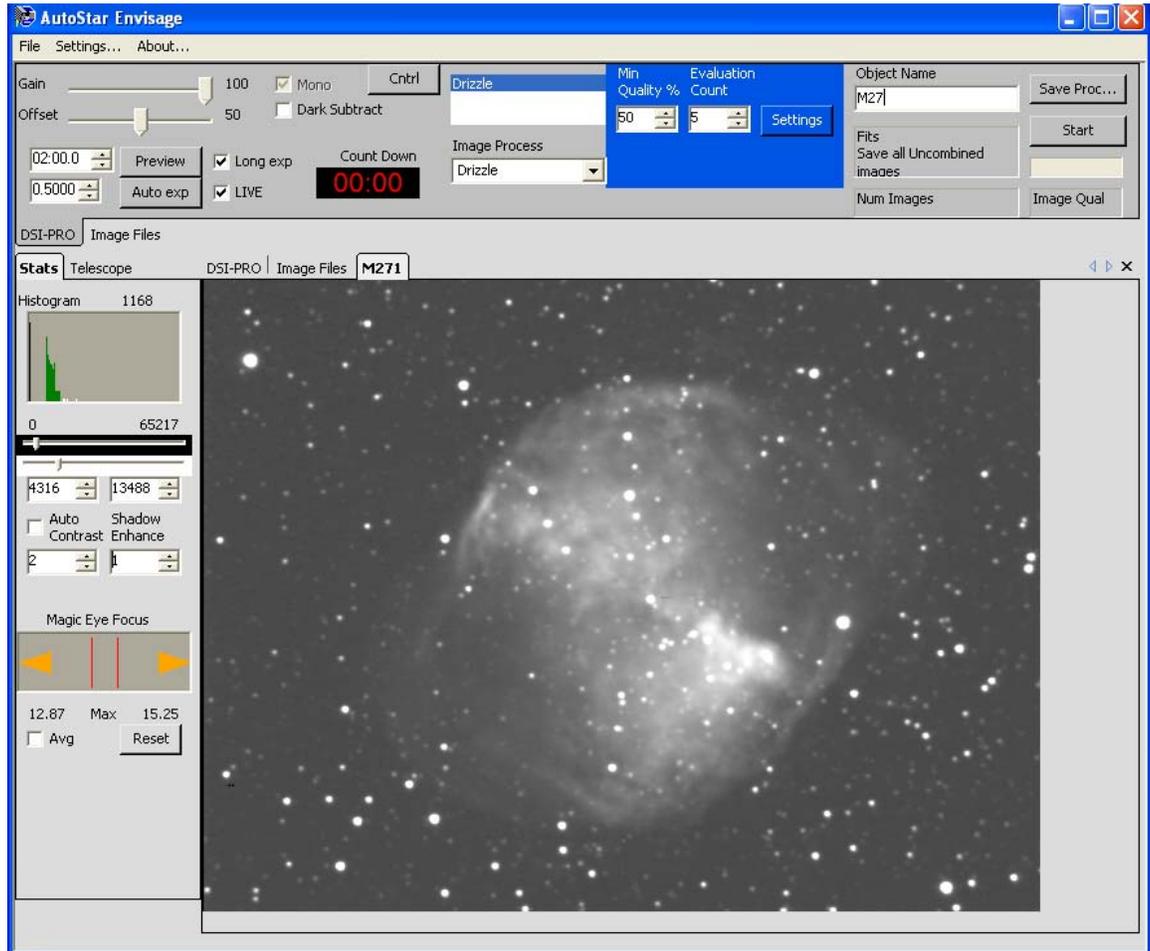
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- 3) Take a test exposure that is of the duration you will use for final captures. This step is very important for selecting the reference stars for the de-rotation process as you will better be able to assess which stars will be usable.
- 4) Adjust the histograms for your image as required. Remember that any histogram settings used during the capture process are saved with the image.
- 5) If you are guiding, either with the imaging DSI or with another guide camera, ensure your guiding has been set up in the telescope tab and guiding is enabled.
- 6) Next, using your left mouse button, draw a small box around your first reference star. One goal here is to select the brightest stars you can on the screen. Since this is being used for re-rotation, it is also advisable to select a star away from the center and closer to the edge of the image.
- 7) Next, simply locate another star as far from the original as possible and draw a box around that star also. The application should then draw a line between the two stars as seen in the image below:



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- 8) Click the start button as you normally would. At this point, the camera should begin acquiring images and stacking them. Take special note of the first few images to ensure the de-rotation is being applied correctly and that neither of the stars has been dropped.
- 9) After the number of exposures desired has been captured and stacked, click the stop button. The image should appear as seen below:



As you can see in this image, as compared to the test image, it appears to be slightly dimmer or slightly washed out. This is due to the number of images I used in this capture, only 7. You will find that the greater number of images captured will result in not only a greater signal to noise ratio, but when using drizzle will also cause the image to become brighter naturally over time. If too few images are used, you may find your images slightly dimmer.

Before I close this section, there are a few items that should be taken into consideration when using the drizzle de-rotation:

- a) Drift - If your mount has any significant amount of drift, one of your stars could drift out of the FOV and your following images would not stack correctly. If you think that you may drift in a particular direction, I would

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- recommend you select a star further in from that edge.
- b) Rotation - A similar issue to drift. If your rotation would drive the stars off the chip, then again you would want to select stars closer to the center.
 - c) Star Magnitude – Ensure that both stars are bright enough to effectively be tracked by the drizzle software and that the squares you draw around them are large enough to take into account expected drift. If the stars are too dim, the tracking system may drop one or both. Be sure to test this prior to starting the capture process.
 - d) Due to the processing required by the drizzle technology (vs the standard track and stack), you may find that there can be up to 10 second delays between each image capture. Depending on the speed and memory of your computer, this may be much shorter and hardly noticeable.

Creating Mosaics with Drizzle

Another feature of the drizzle software is its ability to create mosaic images on the fly during the capture process. While the ability to create mosaics is not necessarily inherent to the drizzle technology, the ability of the software to create any size output image and place pixels on the resultant image at any location means that creating a mosaic fits well within this implementation.

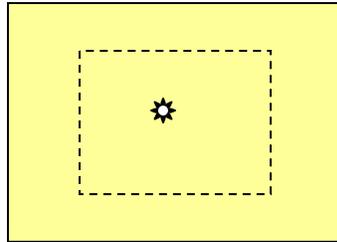
The Envisage software creates a mosaic by establishing the size of the output image based on the parameters supplied in the Settings Dialogue. The software then guides the scope in a circular pattern during capture such the images taken will cover an area of the sky equal to the image size selected. For example, if you have entered an Extended view value 1.50 (1.5 times the standard image size), the application will create a “canvas” for that image that is 960 x 720. It will then slew the scope during the capture process so that images will be captured that are 320 pixels to the right of the original and 240 pixels below the original.

As each image is taken, commands are then sent to the scope to slew slightly in a specific direction for the next capture. The captured image will be slightly shifted in that direction from the previous image captured. Based on the reference stars selected, that image is then overlaid with the images already captured extending the edge of the output image. Once the shifted images reach the edge of the designated canvas size, the software will shift the direction and repeat this until the entire canvas is filled. Also, since the shift between each capture is only a few pixels, the resultant image still ends up have many images with which to combine thereby still increasing the signal to noise ratio.

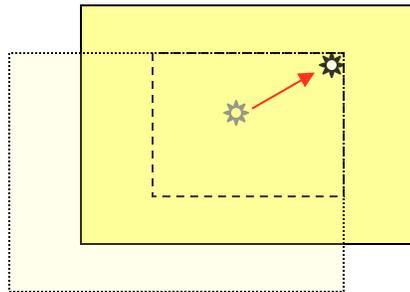
The diagram below shows you how the software maps out the new image and the way it works its way around the screen to create a mosaic. Once it starts the capture process, the star is first moved to a designated location in the top right of new image, then continues in a counter clockwise rotation till it returns to its starting position. This can be a little confusing when you first see it but will make sense once you have completed a mosaic.

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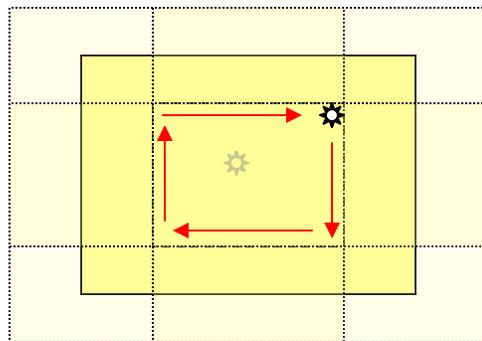
In this example, we are creating our new 960 x 720 image based on our requirements. The small inner dashed square is the pattern that the star must follow to create this new image and the ✨ represents our star.



The next image shows what our new image looks like after the star has been moved to the top right of the image. Remember, this means that the scope is moving in the opposite direction, so moving the star to the top right means when we lay that star back over the original location, the image will have “grown” to the left and down as seen below:



Once the star has made the entire trip around the image, the layout should look as you see it below with the star having returned to the top right position.



Remember that the larger the extended view value you enter, the larger the resultant image and the longer the process is to take the image. If the extended view is set to its highest value of 2.00, the star is moved to the farthest point possible in each corner to create the mosaic.

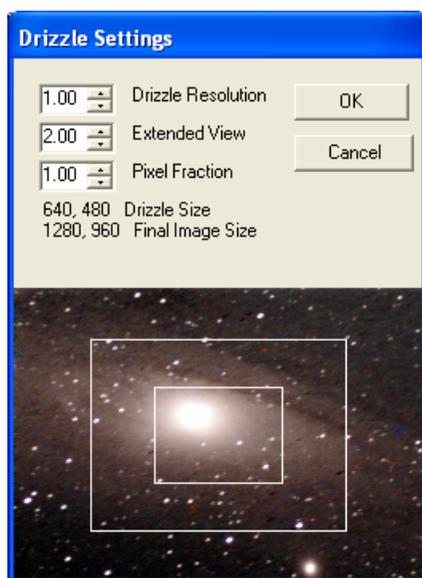
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Before getting started on the steps for creating a mosaic image, there are a few issues that should be understood.

- 1) In order for the application to control the scope for creating the mosaic, the user must be using either a Meade telescope that allows guide commands or an interface to their telescope that can communicate with the Meade software to issue guide commands to the mount.
- 2) In order to effectively move the scope during a mosaic imaging session, the scope guide camera **MUST** be the same as the imaging camera. Using a guide camera that does not have the same FOV as the imaging camera may cause your mosaic to fail due to loss of the reference star and clipping.
- 3) Planning your imaging session when creating mosaics is critical due to the time required to carry out this procedure. Since the scope is slewed only a few pixels prior to each image capture, the duration of the entire operation can be very lengthy depending on your settings. Obviously, if the settings are set to 2.0 making the largest mosaic possible and your capture times per image are 2 minutes each, you can see that you may not have enough hours to actually complete the task. Ensure that your setup and the requested output size are mathematically within the capabilities of your imaging session.

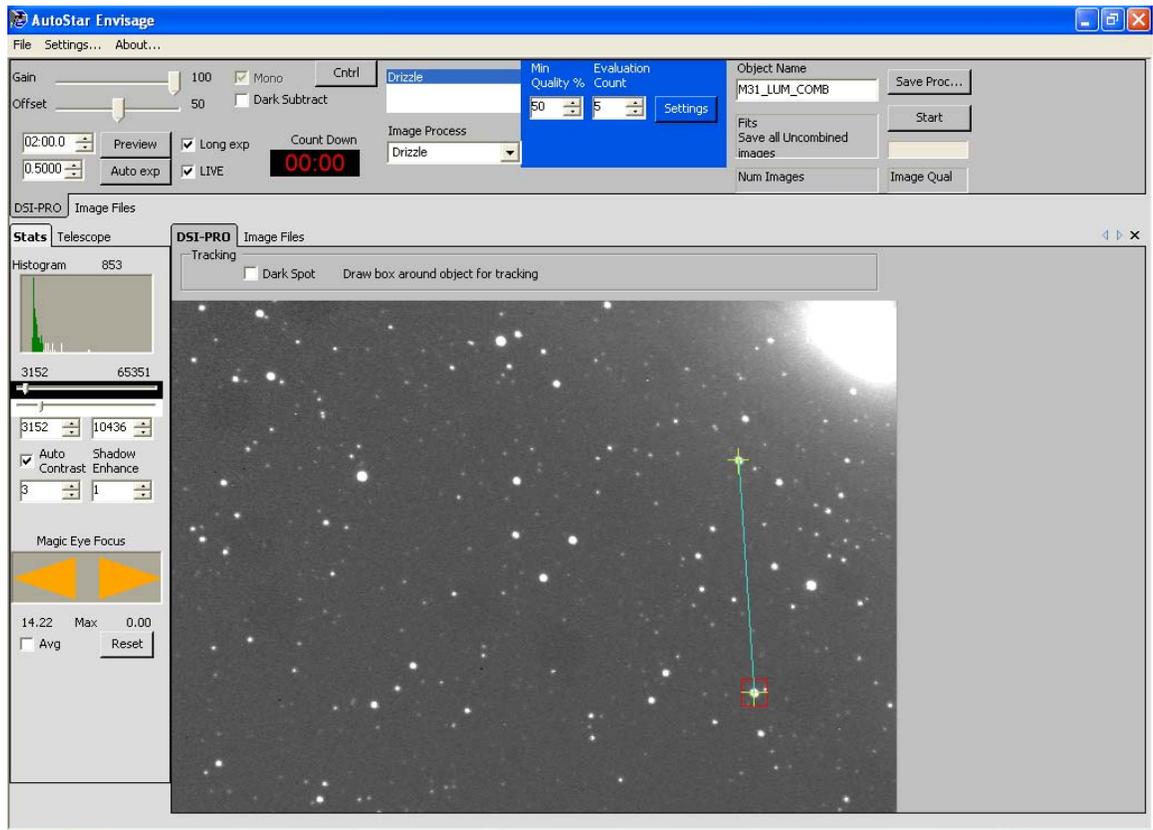
To start, ensure you have setup your scope and camera as you normally would. One thing I have found helpful here is to do a small set of test images ahead of time slewing the scope between each image to “map” out the area I want to image. This will give you a good idea of how large you need to make the output image. Also, you should ensure that guiding (using the imaging camera) is setup and ready to go.

- 1) Ensure Drizzle is selected from the Image Process drop down list and then Open the Drizzle Settings dialogue. Enter the Extended view that you have calculated you will need for your image as seen below.



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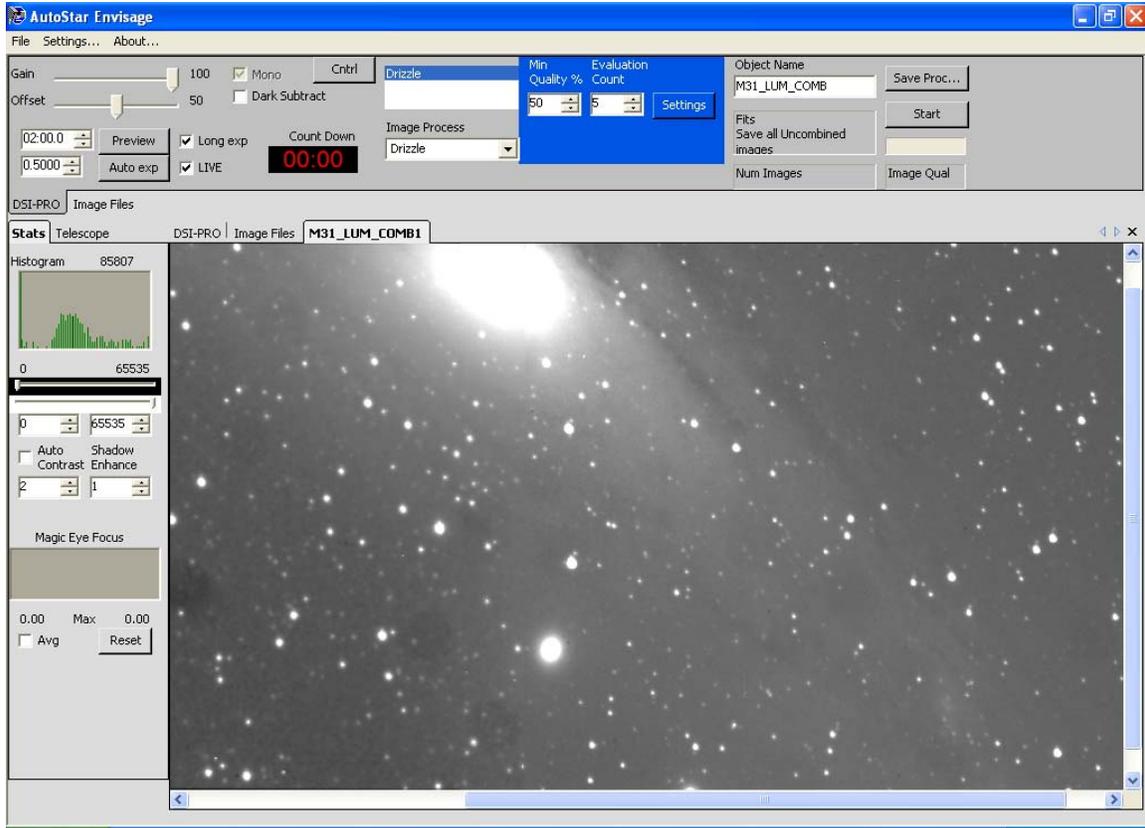
- 2) Click the OK button to save your settings.
- 3) Perform a test exposure that is set to your expected final exposure time. As with the de-rotation process, this will help in selecting the appropriate star (stars) that will be used for guiding and reference.
- 4) Next, select your star (or two stars) that will be used as reference and guide stars during the process. **Note:** If you select two stars for reference and de-rotation, the first star is used as the guide star for moving the scope but your image size will ultimately be dictated by the placement of the two stars in all the images meaning your final image may be smaller than you selected. This ensures that the two stars remain in all images.



- 5) You are now ready to begin the capture and mosaic process. To begin the mosaic, simply click the Start button. The software will take the normal number of evaluation images and then begin guiding the telescope to move the guide star around the pre-determined pattern to create the mosaic.

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- 6) As the capture process continues, you will see the image being built in the output screen tab. The image below shows the process part of the way thru its imaging cycle.



As previously stated, the process of creating a mosaic can be very time intensive. Ensure that you have planned accordingly for your imaging session. The following is a list of things you might consider when setting up:

- a) Use the smallest extended view value that you possibly can. The smaller this value is, the faster the process will complete.
- b) As with the De-rotation setup, ensure your guide stars are bright enough in the captured frames so they are not dropped during your imaging session.
- c) As already noted, remember that the final image size will be reduced if two stars are used for reference during the capture process.

Enlarging your Images during Capture

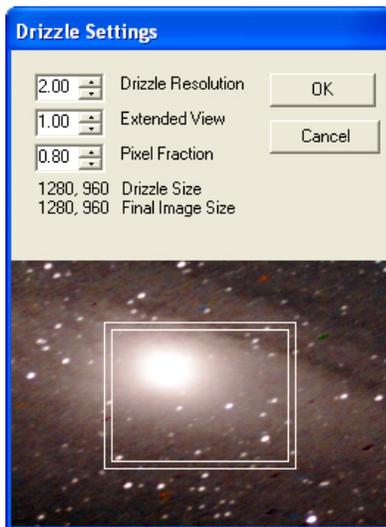
The last Drizzle feature of the Envisage software I will cover is the ability to enlarge your images on the fly during the capture process. While this particular capability doesn't seem to get used as much as the others, I happen to think that it can be a very powerful tool, especially when it comes to processing your images later. I have found that by processing the images at double their size and then reducing them back down (if needed) allows you to make much finer processing adjustments.

Drizzle Resolution, the size of the new image as a factor of the original, allows the user to scale their images from the original 640 x 480 up to 1280 x 960. As discussed earlier, the true magic of this is that it is not simply an enlarged image, but by using the drizzle technology, you are actually able to increase the size while bringing out subtle details lost in the original. Thru a combination of setting a higher resolution and a lower pixel fraction, you will also be able to draw out data not found in the original images due to undersampling.

To use the enhanced resolution functions, start by ensuring the scope and camera are ready for imaging and you have taken any test images needed to determine the level of resolution increase you might need. Remember that since the sizes of objects are increased, stars, artifacts, etc may also be increased and as such, poor guiding or polar alignment will also show to a greater extent. These items should be taken into consideration when selecting the resolution you wish to use.

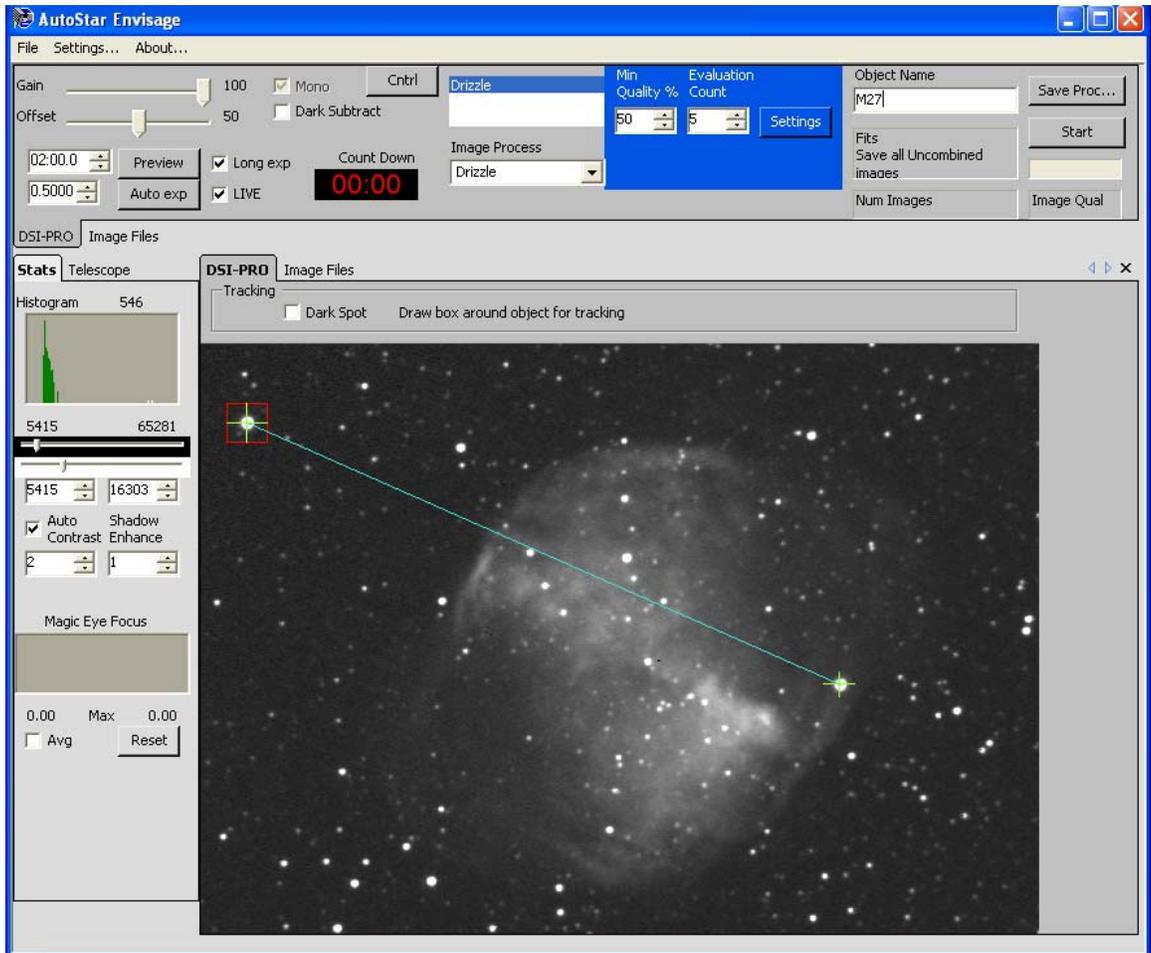
Secondly, you should also determine what Pixel fraction you are going to use. If you plan to capture a large number of images, then you can lower the pixel fraction accordingly. But, if you plan to only capture a few images, the pixel fraction should not be lowered to a great extent. As previously stated, the ability to increase the resolution of an image with Drizzle is directly linked to the pixel fraction selected. If the pixel fraction is left at 1.00, then you will lose many of the advantages of drizzle in the increased resolution image. Likewise, if the number is too low, you may pixelate the image.

- 1) After setting up the camera and scope, (ensuring Drizzle is selected), open the Drizzle Settings dialogue as seen below.



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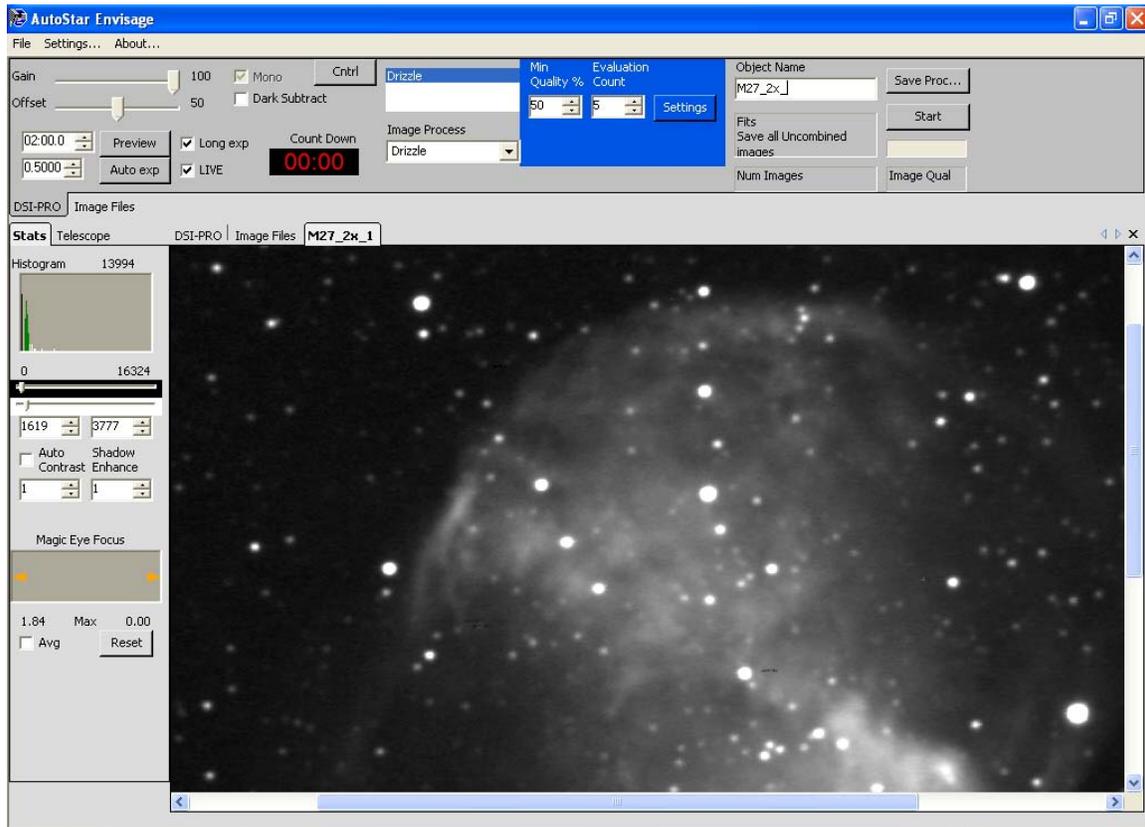
- 2) Set the resolution of the new image that you desire in the top scroll box and the Pixel Fraction to use in the lower scroll box. For this example, I have set the image resolution to 2.00 (twice the original size) and the pixel fraction to .80.
- 3) From the main camera tab, select the star (or stars for de-rotation) that the software should use for guiding and reference as seen below.



- 4) To begin the capture process, click the Start button, the new image will be displayed as it is captured.

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- 5) As can be seen in the image below, the new image is twice the size of the original with the detail retained and no pixilation noted.



Conclusion

In this document I have attempted to provide you with a brief overview of the drizzle technology, how it is implemented within the envisage software, and how you can use it to enhance your images captured with the DSI or DSI-Pro.

In Part II, I will discuss the capabilities of this software for post-processing.

Bibliography

- (1) **Handbook of Astronomical Image Processing**
Richard Berry and James Burnell
Publisher: Willmann-Bell, Inc, 2005
Pgs. 29-30

