Introductory Guide to Planetary Imaging

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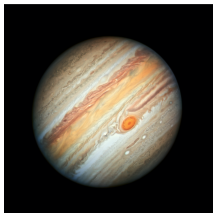
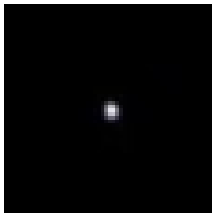
March 2021

1 Introduction

Everyone at some point in their lives, have looked up to the night sky and wondered; what all magnificent things must they be missing being bound to Earth. As a kid when i got my first telescope, i was thrilled i could use it to spot planets in a higher definition than viewing it with the naked eye. I was a bit disappointed when planets like the Venus, Mars, Jupiter and Saturn didn't glow up in vibrant colours like they did in the books and looked like tiny zoomed-out versions of regular stars.
But, with the magic of Planetary Imaging it would be possible to convert pictures you take from your telescope into beautiful and bright outputs.



(a) Actual Close-up Image



(b) Looking Thru a Telescope

Figure 1: Image of Jupiter

2 Advantages of Planetary Imaging?

- Light Pollution[2] has always been a thorn in Astrophotography. However, light from planets pierce right through the atmosphere. You can make fascinating planetary images even if you live in the middle of a city.

- Unlike Long Exposure photography, Planetary Imaging is a short and sweet process. It doesn't take all night.
- The equipment you need for Planetary Imaging is quite modest.
- Planets keep rotating and its exciting to keep a regular track of different sides of the planet. Every night is different.

3 Lucky Imaging

How to get such a fine resolution from so far away? The trick to this is to freeze the 'Seeing'. Seeing refers to the amount of turbulence you get in your image. You have to take lots and lots of really fast exposure by recording at very high frame rates.
Later we will check for the ones with good exposure and sharpness and stack them together and we will sharpen the end product to get a really good photograph of the planet.

4 Preparation

The following are pre-requisites before you go out and start the imaging:

- Find out what planets are near opposition[1].
- Check the forecast for Seeing at `https://www.meteoblue.com/en/weather/outdoorsports/seeing/`
- Find out planet's meridian transit time, time at which they are at the highest in the night sky.
- Allow temperatures to equalize before you start Imaging. Tube currents can lead to bad images being produced. You can prevent this by making sure you keep the telescope outside for at-least thirty minutes before you start the Imaging process.
- Try not to shoot over pavements or houses. Heat rising from these materials will definitely mess-up your Seeing.

5 Software Required

In this tutorial, you would be working with the following tools:

- Capturing: FireCapture
- Stacking: Autostakker
- Sharpening: Registax
- Final Tweaks: Photoshop

6 FireCapture

- When you first click to open the software, you will be presented with an option to select your camera interface. Select a camera that you could connect to your laptop and place the camera onto the support of your telescope. It is quite possible the FireCapture would auto detect the camera and you wouldn't even have to go through this step. If you lack a telescope you can go ahead and use the 'Dummy Camera' option. You would be able to process upon the sample data that software offers.

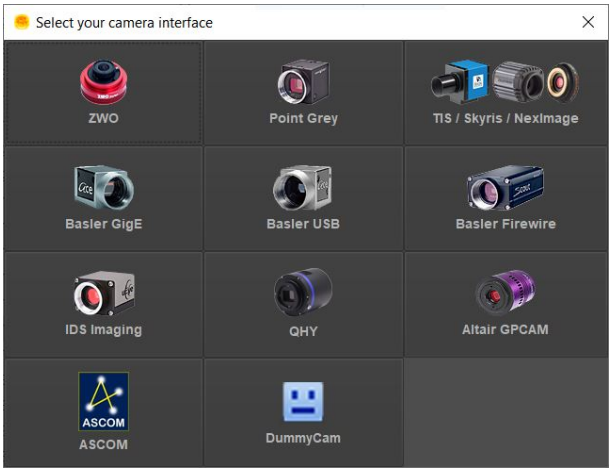


Figure 2: Introduction Window

- After choosing an interface you will be greeted with the main screen. Quickly your attention will be diverted to a screen(WHITE-BOX) that is being recorded by your camera. If you have already focused your image towards a planet, you will be able to see it's fabricated recording on the screen.The image would be in black and white but you would be able to convert it into coloured by using 'Debayer' tool(GREEN-BOX). A dummy camera, by default, would show you the image of a planet. You can even select other planets under the capture option(YELLOW-BOX).

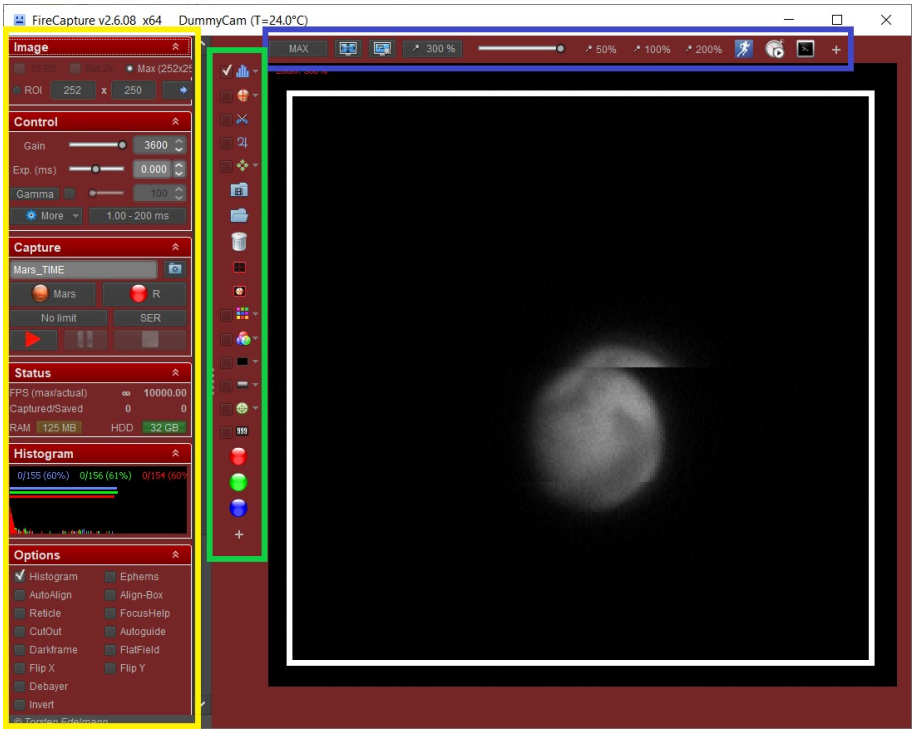


Figure 3: FireCapture Main Window with 4 separate areas marked with YELLOW, GREEN, BLUE and WHITE Boxes

- In the capture window(YELLOW-BOX) make sure you have selected the right planet. In our case we would like to export the recording into '.ser' format. Make sure you have selected it.

- Next let's set up Gain and Exposure in the Control window(YELLOW-BOX). The trick is to get exposure as small as possible without shooting up the Gain. Too much of Gain gives you a grainy image. With a camera you would be able to see a blue range on the Gain slider-widget. This best range. This is going to vary on the planet you are viewing at and how far the planet is.

- Next on the list is to set the frame capture rate. This will depend on the properties of your laptop. You can draw a rectangle around the planet to make the region of interest smaller. But make sure that the planet doesn't move out of the region while tracking.

- Total exposure time in the Capture window(YELLOW-BOX) will generally be set to 'No Limit'. But certain planets like Mars rotate as fast as Earth does so we will have to limit the rotation by limiting the time

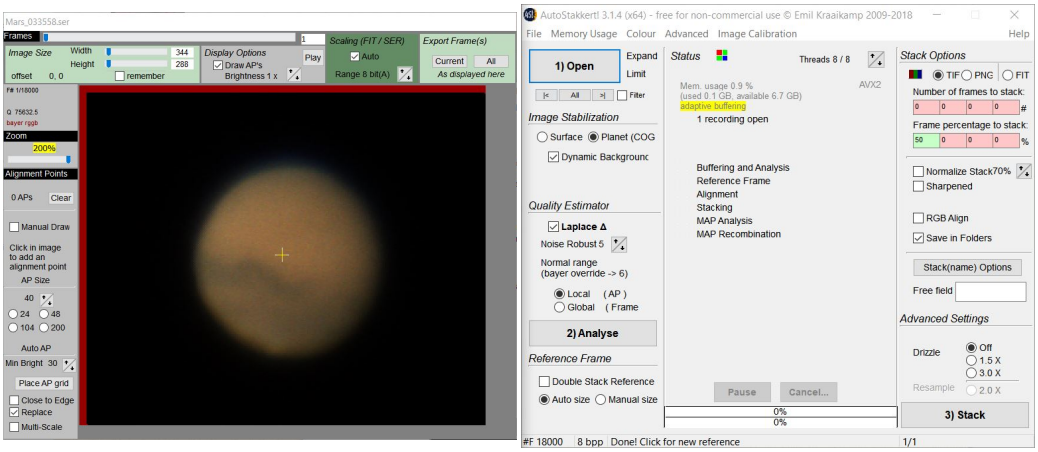
so that it doesn't affect the exposure. For Mars and Jupiter, you can set the limit to 300 seconds. This will automatically complete your capture session in 5 minutes.

- Before you start recording, make sure your tracking is good and you have a good polar alignment on your telescope. You want the planet to stay centered while recording as much as possible,

- When you are good to go, click on the red Play button on the Capture window(YELLOW-BOX). When you are done, FireCapture will produce an 'ser' file.

7 AutoStakkert

After capturing some good data of your planet, we are going to use Autostakkert. Autostakkert will be used to select the best frames and align them and stack them.



(a) Window 1

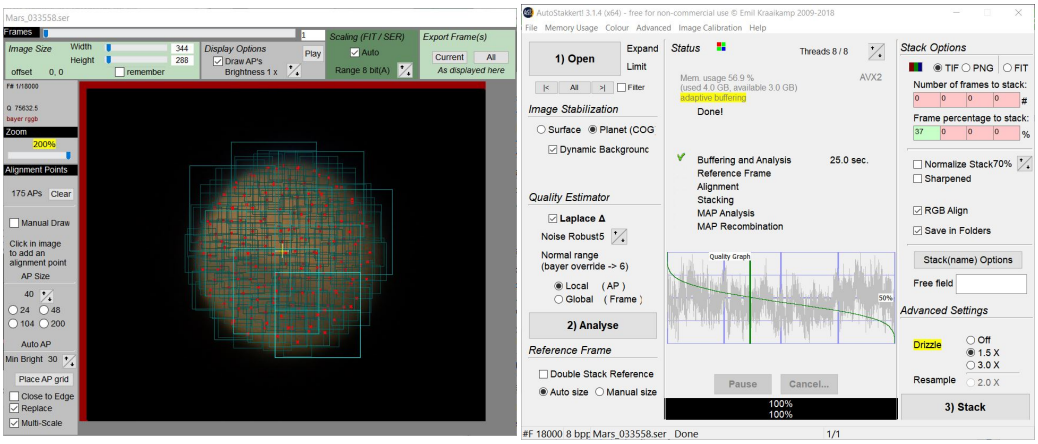
(b) Window 2

Figure 4: AutoStakkert

- Open Autostakker and Click on 'Open' Button(WINDOW-2) and select the 'SER' file of your planet in the previous step. After selecting you will be able to see the preview on the window of your application.

- If you want to visualize your data, drag the 'Frames' slider(WINDOW-1) and you will be able play back the 5 minutes video data.

- Now there are 2 ways you can set your alignment points. You can do it either automatically or manually.
- For automatic placing, first identify if your planet is of small size or large. Planets like Mercury and Mars can be considered relatively small and so you could set their AP size to 24(WINDOW-1). For larger planets go for 48 or 104. After selecting alignment points check the 'Multi-Scale' checkbox and click the 'Place AP grid' button.
- For Manual Alignment, you can manually click on areas of your planet with high contrast and varied features. If you feel like you have made an error, you can always start again by clicking the 'Clear' button.
- In the Main Window(WINDOW-2) make sure to have 'Planet' checked in Image Stabilization Window. 'Surface' Option should be selected for the moon. Tick 'Dynamic Background'. At last click on the 'Analyze' button and wait for the software to do its thing.
- After its done analyzing, you will see 'Quality Graph' being generated. This graph shows you the large patterns in the degradation of seeing during the 5 minute capture. Graph will be divided into periods and some periods will be better than others.
- The green line on the graph will show you what it would look like if we were to order all of the frames in the order of their quality.
- Next what you have to do is hover your mouse on that green line until your pointer align with the 50 percent mark. When you reach the position 'Ctrl+Left Mouse Click'. This will separate the data into 2 parts and now you will be working with the better percentage of that data. If you see on the top right side of the video you would see a number under "Frame Percent to Stack". You will be taking the best 'n' percent of the data to achieve your goal.
- Make sure you check 'RGB Align' in the Stack Options(WINDOW-2). No need to Normalize or Sharpen. We will use addition tools to do that.
- 'Drizzel' in Advanced Settings is able to capture some addition sub-pixel details using its techniques. It can help scale up your images. But this trick only works if you have good enough seeing to support it. The sweet spot is to set 'Drizzel' value to 1.5 . If you set it to 3 you wont get much result and only increase your computation time.



(a) Output Window 1 (b) Output Window 2

Figure 5: AutoStakkert Output

- Now all that is left is to click the 'Stack' button and let it complete its process. Your output would be a '.tif' file and might look blurry, but we will fix it in the next step using RegiStax.

8 RegiStax

- Even though your output file after processing through AutoStakker looks small, it has lot of hidden data that can be pulled out to make image more detailed. For this we will use RegiStax.
- To import the .tif file go to 'Select' and choose your file. If prompted, do stretch the intensity levels.
- The way Registax works is that every one of the layers in the wavelets settings corresponds to a different scale of features you want to sharpen. For example 6 would correspond to largest features and 1 would correspond to smallest.
- There is a slider that controls how much of the level is blended into your final image. We can also control the 'Denoise' and 'Sharpen' value. Denoising is independent of the slider value. We will use Denoise to remove the noise that appears while sharpening the levels and use the sharpening to get the most information out of the file.
- You can start with level 3 or level 4 and crank up the values to the top. By default the sharpen value of the top would be set to 100, but you

can increase it further when needed. At whichever point you start, you need to move down to 1 .

- Use the checkbox at every layer to quickly toggle on and off and see the sharpening difference.
- If you sharpen too much you might get a grainy image. To undo that you can increase the value of 'Denoise'. Denoising should start from 1 and move to upper layers. This is because denoising can majorly be solved at layer 1. Still if something persists you can move up and deal with the lesser needed changes.
- If your image starts looking cartoonish or blotchy it might be due over-sharpening.
- You would notice a ring kind of effect around the brighter edge of your image. This is known as an Edge Rind Artefact and is an optical effect that is caused by not having an infinite aperture on your telescope.
- You can remove this effect by 'Denoise/Deringing' in the functions menu. Since it appears on Brighter edges, we would check the 'Brighter side' checkbox and move the slider until the effect dies down.
- If your planet is not positioned correctly, you can rotate the image from the functions menu by selecting 'Flip and Rotate'.

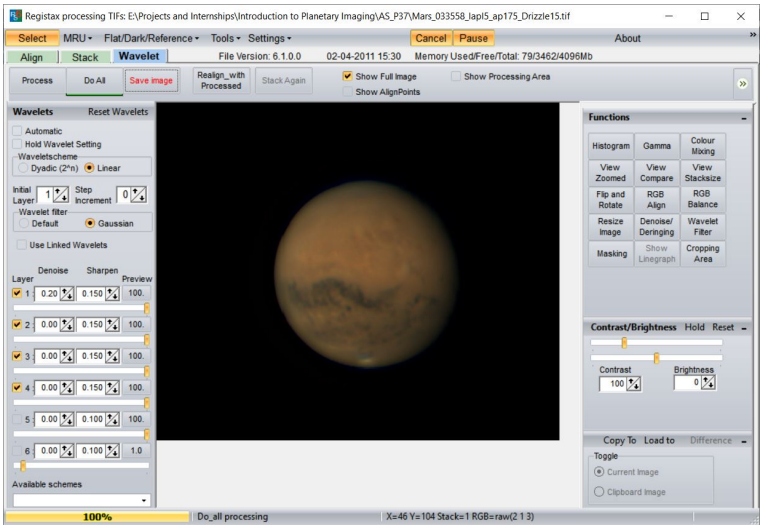


Figure 6: RegiStax Window

- Save you image. If you save it in .tif format it would be easier for you to make changes in the future, Now all that is left is to apply some finishing touches in Photoshop. This step in not mandatory and the image looks fabulous even at this current stage. So if you don't have Photoshop its alright.

9 Photoshop

All you would be doing in Photoshop is adding some minor details:

- In Photoshop go to Filter → Sharpen → Smartsharpen. Play with 'Radius' values. If introduces some noise increase the 'Reduce Noise' values.
- You can use stamp tool to hide the ring effect if you couldn't properly remove it using Registax.
- One principle thing to improve would be saturation. In Image → Adjustments select 'Hue/Saturation'.

That's all there is to do. Save your image and you are done.

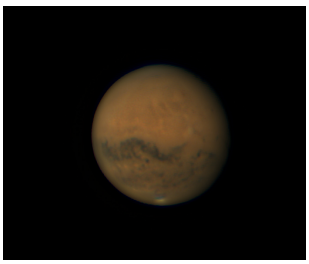


Figure 7: Final Output Image of Mars

10 Conclusion

And there you have it. With a little determination and a small help from Planetary Imaging tools you are finally able to imagine and construct a fullfilling image of a planet you always wanted to see, an image you always wanted to experience.

References

[1] Scott Levine. What is an opposition? — astronomy essentials, 2020. [Online; accessed 29-March-2021].

[2] Wikipedia contributors. Light pollution — Wikipedia, the free encyclopedia, 2021. [Online; accessed 29-March-2021].