Planetary Processing

This freeware takes the drudgery out of stacking planetary videos.

Emil Kraaikamp The long-established technique of lucky imaging is unquestionably the best and easiest way to record high-resolution photos of the Sun, Moon, and planets. Using high-speed digital cameras, amateurs record thousands of video frames of their chosen target in short, multi-gigabyte files, which are later sorted to select the sharpest frames to combine into a final, detailed result.

The problem then becomes working through all the data — it's easy to accumulate several dozen to more than 100 gigabytes of video files in one evening! Distilling these files is a time-consuming process. The most popular program, *RegiStax 6*, can't batch-process these files well, so users have to process each video individually.

This led me to write *Autostakkert!* (**autostakkert.com**), a program whose primary function is to stack the best parts of video frames with only a few mouse clicks, permitting you to concentrate on processing your images. Here's how it works.

Determining Image Quality

Begin by opening the files you'd like to process by clicking the **1) Open** button and navigating to the folder where your files reside, or simply drag and drop them into the program. The first frame of the first file will then be displayed in the frame view window.

The first action *Autostakkert!* (now on version 2) needs to perform is an evaluation of the quality of your video frames. To do this, it needs to stabilize the individual frames (correcting tracking errors) before it performs alignments on a finer scale.

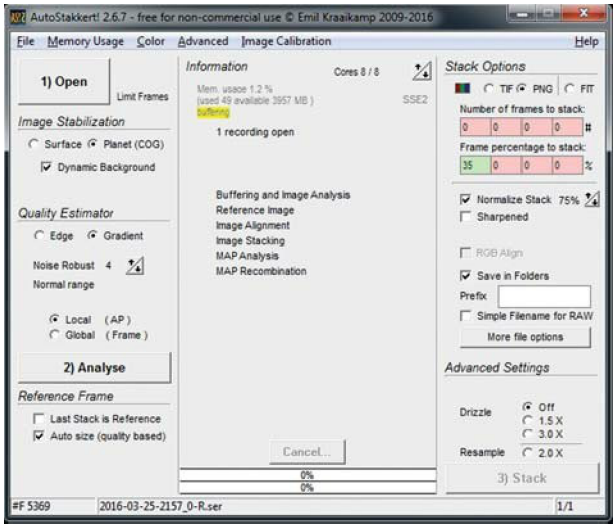
The software does this in one of two ways. For planetary recordings, the Planet (COG) mode is implemented, centering the largest bright group of pixels (the target planet) in each frame. By default, it automatically determines the threshold that separates the bright pixels from the background. You can often significantly speed up the process by making sure the width and height — in the frame view — are set as small as possible, encompassing only the subject.

In Planet (COG) mode, the target will be centered by default. You can change this composition and move the planet around the field by holding the Shift + left mouse button while dragging the planet around the frame. This is most useful when offsetting Jupiter or Saturn to include their largest moons in the field of view. Planet (COG) mode ensures the planet is also aligned from one recording to the next, making post-processing much easier, particularly if you're combining monochrome videos shot through color filters into a color image, or assembling a time-lapse animation.

The other option for the stabilization of individual frames is Surface stabilization, which is best used on

with Autostakkert! 2

close-ups of the Sun and Moon. Surface allows you to choose and track one particular feature throughout the video. Use Ctrl and click in the frame view to place an alignment anchor on a prominent feature such as a sunspot or a high-contrast area on the Moon. You can also resize the alignment anchor by typing 1 to 9 on the keyboard, which is especially useful when you want to track on a very small feature. The smaller the alignment anchor, the faster the surface stabilization runs.



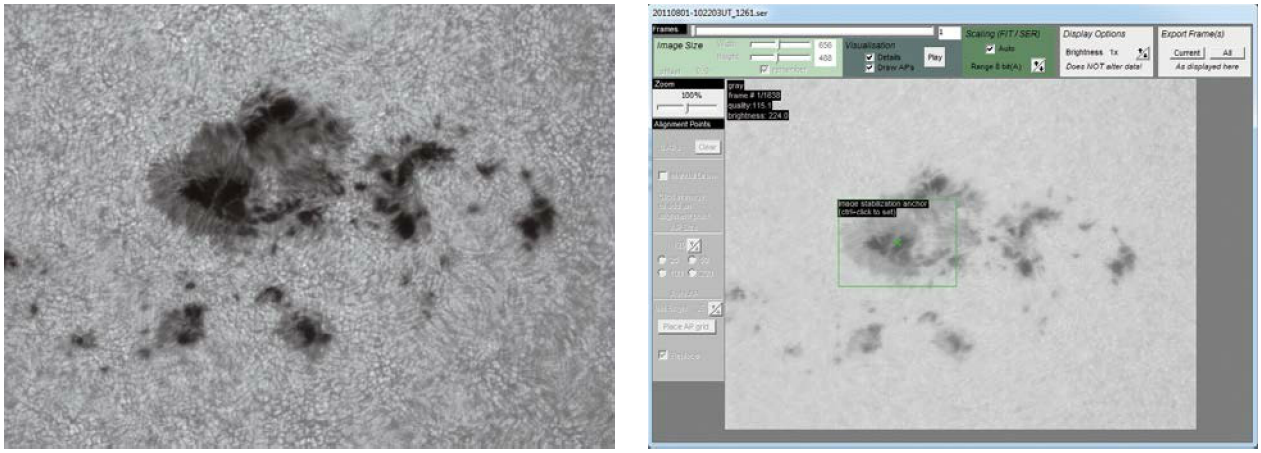
CONTROL PANEL The program's main user interface is a sub-window that appears alongside the frame view window. Key actions are located along the left and right sides, while the center column displays the progress of actions in process.

STACKED Stacking planetary videos is often a time-consuming process, but it doesn't have to be. *Autostakkert!* is a time-saving program that lets you batch-process many videos to produce high-resolution images of the Sun, Moon, and planets, like the detailed results above. All photos courtesy of the author.

The next step is to determine which of the two available Quality Estimator functions should be used to evaluate the frames in your recordings. The Edge quality estimator is based on edge detection in images, which works best for the smallest planets, particularly Mercury and Venus. Edge is designed to examine the sharp, sunlit limb of your target, so you'll want to uncheck the selections around the planet that are near its shadow side.

The other option is the Gradient estimator. As the name implies, it detects gradients on your target at a scale that is determined by the "Noise Robust" levels in the image. Typically, 4 is a good starting point, but for noisy images or videos shot at very high focal ratios, you might achieve a better result by increasing this setting to 6.

Gradient has another option that determines whether the frame quality will be estimated around each alignment point, called Local (AP), or by examining each frame in its entirety, called Global (Frame). Best results are most often achieved using the Local estimator, because it allows



BOILING ATMOSPHERE *Left*: This single frame of a white-light solar recording shows "seeing cells" distorting some areas of the image much more than others. *AutoStakkert!* extracts only the sharpest areas in each frame. *Right*: A high-contrast area is chosen as an anchor point to roughly align the video.

the software to select the best areas of each frame. The Global setting is useful when the background is changing in brightness, which can happen during daytime imaging with changing transparency. The Global setting ensures that each alignment point uses the exact same set of frames for stacking, thereby avoiding brightness inconsistencies in your final stacked image.

After selecting the Quality Estimator, it is time to click the **2) Analyse** button, which will start the quality estimation of all frames and, in the case of a surface recording, will also perform the surface stabilization. Image stabilization is a crucial stage in processing the recording, so when it's complete, you should check how well this was executed automatically. Go to the frame view window and drag the Frames slider around to ensure that each frame is coarsely aligned and only small movements are still visible. If there are large movements visible after surface stabilization, try placing the alignment anchor on a different feature and rerun the analysis stage.

When image analysis is completed successfully, the label of the Frames slider turns green and the frame view window shows all the frames sorted by their average quality, from best to worst. The main window will also show a Quality Graph, indicating the frame quality over time (as a gray line) and the distribution of the sorted frame qualities (green line), scaled from their best (top left) to worst (bottom right) values. By clicking on the Frames label, you can switch between browsing through the quality sorted or unsorted frames.

The Quality Graph will give you an indication of how many frames you might want to stack; typically anything below the horizontal 50% quality line (halfway up the image) can be ignored. By pressing Ctrl and right clicking in the quality graph at the point where the majority of frames are below the 50% line, you can automatically set the corresponding percentage of frames you want to stack. However, this quality graph only gives a rough indication, and it's advised to check the frames by eye as well, as this gives a better indication of what your frames really look like and how many of them you might want to stack for your recording.

Alignment Points

Now that the quality evaluation is complete, it's almost time to stack your videos. *AutoStakkert!* allows you to make multiple image stacks from the same video simultaneously, using both fixed numbers of frames and/or frame percentage numbers (e.g., you can ask it to always stack 50% of all the frames). This is particularly handy when you are not sure how many frames you should stack. This percentage number strongly depends on the imaging conditions (most importantly, the seeing). A good rule of thumb in planetary imaging is to use about 50% of the frames; use more when the seeing is very good and fewer when the seeing is poor. When you have a very bright subject, such as the Moon or Sun, fewer frames are often preferred.

To correct for fine-scale movements caused by seeing distortions, the best results are produced by using multiple alignment points (APs). These APs define regions of the images the program will analyze and track to compensate for seeing distortions. Each of these APs uses a local quality estimation to build up a unique subset of the best frames for that area, allowing the software to build a map of the image as it would appear without gross distortions.

The APs are typically placed with quite a bit of overlap, allowing the program to discard the bad ones. When the contrast is inadequate for a particular AP to track, the resulting blurry stack from that particular AP is ignored and replaced by the data from an adjacent AP.

Determining where and how many APs should be used isn't easy. You can get very good results with the Place AP grid button, which places APs automatically in a grid-like structure. However, manual placement of APs

can often produce notably better results. You can add APs manually by left clicking on your image, and remove APs by right clicking on them. The mouse scroll wheel can be used to change the size of an AP before placement, or by clicking the up and down arrows in the Alignment Points section of the frames window. The best locations for APs are those areas of high contrast in at least two perpendicular directions, providing the program with distinguishable features it can lock onto. Some good areas to place smaller APs are where the rings of Saturn meet the planet, the polar caps of Mars, or the shadows of Jupiter's moons on the planet itself.

Use large APs for areas that contain less contrast; a good example is a large area of lunar maria with few craters. Avoid linear features that may only be tracked well in one direction. For example, when a small AP is placed on top of the edge of the solar disk, details within the disk can suffer if that "line" is tracked inadequately in just one direction. In those cases it's better to use a larger AP, or move it towards the center of the disk, allowing only 10% of black space visible for each AP. You can mix and match different-sized APs, and they can also be placed on top of each other. Always try to cover your entire subject with APs.

Once the APs have been selected, press the **3) Stack** button to generate your stacked results. Check the Save in Folders option, especially if you chose to use several different frame totals in your stacks. A new folder is created for each stack size (or quality percentage), organizing your output nicely. Once completed, you can then import each image into your preferred image-processing program to sharpen the results.

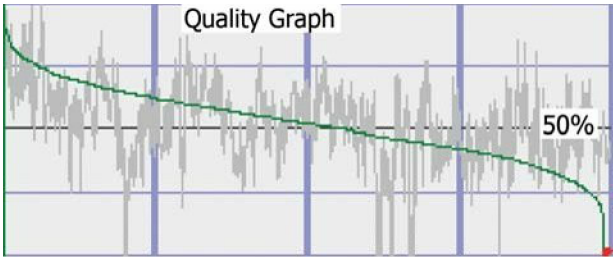
Advanced Features

Autostakkert! includes a few additional features that can help you get the best results from your recordings. They can perhaps even open up more possibilities in your choice of targets.

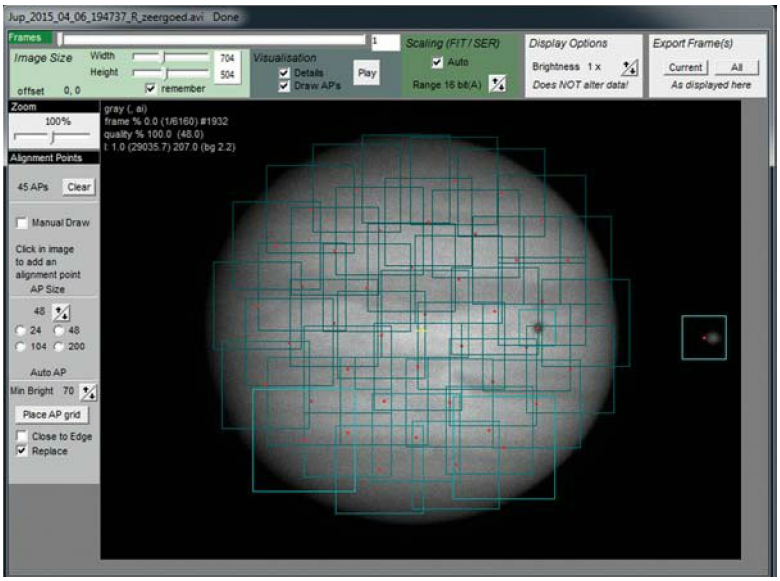
For most planetary imaging, image calibration isn't as necessary as it is for deep-sky photography, but the software includes the option to create and apply both dark and flat fields, which are especially useful for calibrating your lunar or solar recordings.

Normalize Stack is a helpful option only available for planetary recordings. It sets the brightness of the image stack to a fixed percentage and compensates for brighter than normal backgrounds from imaging in twilight (or even daylight). Turning this option on greatly simplifies post-processing, particularly if you're processing many recordings with gradually changing brightness levels. This option also helps maintain a consistent brightness between images when creating animations.

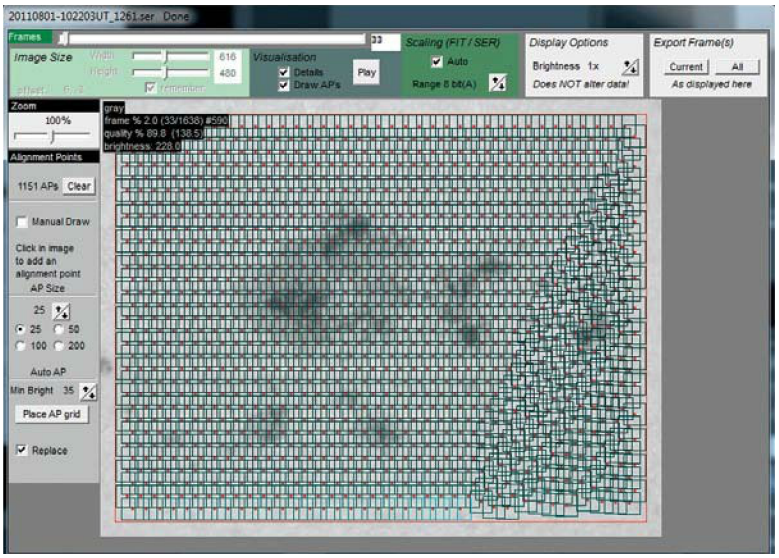
As most planetary images taken with amateur telescopes are relatively small, the program includes two options to deal with them. Drizzle and Resample are



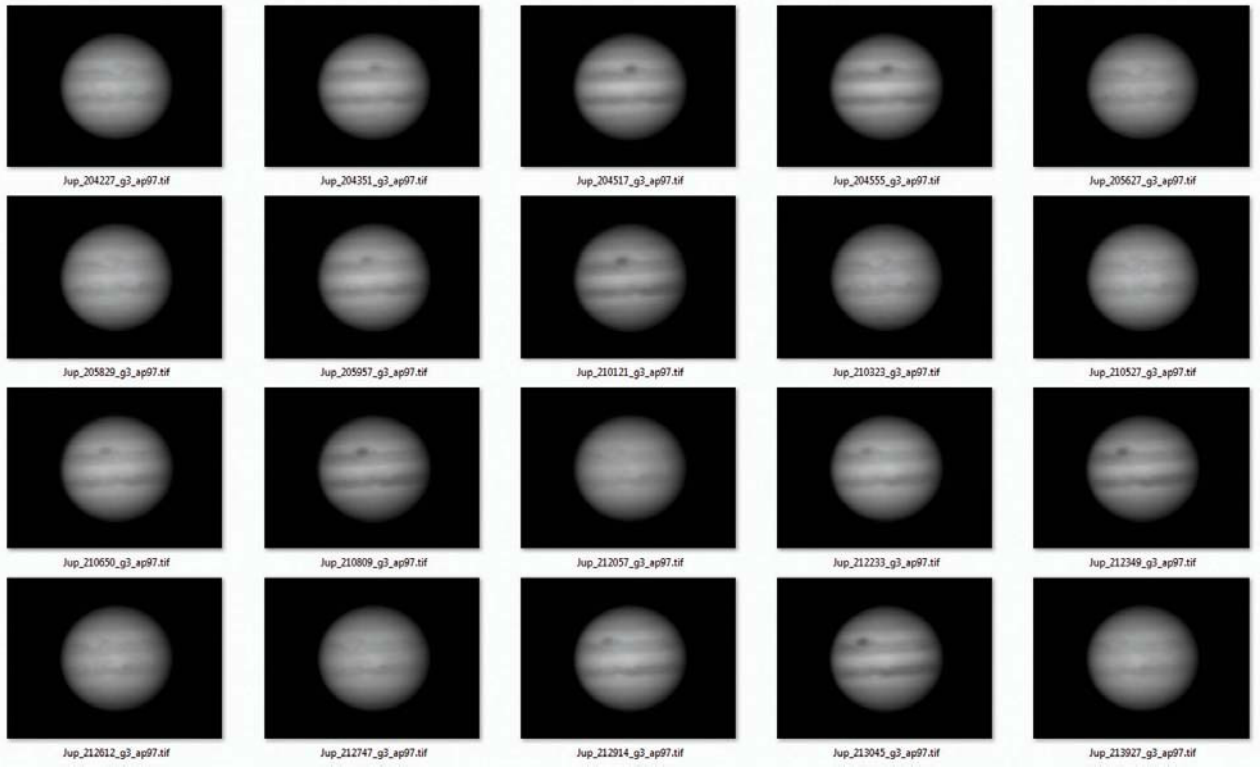
QUALITY ASSESSMENT After analyzing the first video, *AutoStakkert!* produces a quality graph. The gray lines show the quality of the unsorted frames, and the green line displays the distribution of the quality sorted frames.



MULTI-POINT ALIGNMENT Setting alignment points in your video can be performed manually, or you can click the Place AP grid button to allow *Autostakkert!* to choose alignment points automatically.



STACK OPTIONS The program allows you to generate multiple stacks from the same video. Type in the number of frames (or percentage of frames) in the pink boxes, and they'll turn green when active. Be sure to check the Save in Folders box to keep the output files organized.



FINAL OUTPUT Upon completion, *Autostakkert!* produces a folder for each of the stack options you chose, ready to be imported into your favorite planetary processing software for sharpening, deconvolution, or any additional processing you choose.

output options in the program to upscale your images. Resample enlarges the image using a bicubic interpolation algorithm. Drizzle, on the other hand, is a technique developed for the Hubble Space Telescope that takes undersampled data and improves the resolution of your final image. Both drizzling and resampling are performed during the stacking process, allowing sub-pixel alignment accuracy.

DEEP-SKY STACKING *Autostakkert!* can also stack deep-sky images to take advantage of the superior resolution afforded by short exposures. This detailed photo of edge-on spiral galaxy NGC 891 was recorded with a 16-inch f/5 Newtonian reflector and Point Grey Research Blackfly IMX249 camera and color filters. A total of 3,300 one-second exposures were stacked to produce the luminance image, while 100 four-second exposures were stacked for each of the red, green, and blue images.

When processing raw color recordings taken with color cameras, *AutoStakkert!* performs on the fly "drizzle debayering" (*S&T*: May 2014, p. 72). This technique doesn't perform debayering per frame, but instead relies on small movements in the recording to fill in the missing information between the pixels of the Bayer filter. This results in more details than the interpolation of regular debayering methods and produces a final image stack that is comparable to images shot with the tri-color method.

Finally, *Autostakkert!* isn't limited to processing planetary images. I've had excellent results shooting deep-sky objects with the lucky imaging technique that resolve extremely small-scale features in bright galaxies and planetary nebulae. This requires a fast telescope with plenty of aperture, as well as a high-sensitivity camera. Fortunately, both are readily available today.

This tutorial should allow you to get the most out of your planetary videos, without having to shepherd each one through the program individually. This should free up your valuable time to explore additional post-processing techniques. I continue to improve *Autostakkert!*, so if you have any reasonable suggestions on advancing the software, email me at **ekraaikamp@gmail.com**. ✦

Emil Kraaikamp *shoots the night sky from his favorite observing location in the Dutch province of Ruinerwold.*