How do I remove airplane or satellite trails from my image stacks?

Trails caused by passing aircraft or satellites are a common curse of our industrialized society, and imagers living in urban areas are often limited in the length of an exposure before a satellite or airplane leaves a bright track through the image. An imaging philosophy often used is to shoot stacks, with individual exposure times just long enough to reach the "threshold of pain" resulting from discarding an image (e.g. it is easier to throw out an 8-minute image than it is to throw out a 60-minute image).

Median or Sigma-Clip Stacking provide a means of detecting the anomalously bright pixels due to one of these event and removing them when the images are combined in a stack. It also has the effect of

reducing the elongation of star images resulting from having a few images in the stack with trailed stars due to guiding errors. These techniques also very effectively remove cosmic ray hits.

Median Stacking

Median stacking is a process in which a series of images (after optionally being aligned) is examined pixel by pixel. Pixels with the same X and Y coordinates are sorted, and the median, or middle value, is retained, and all the other pixel values are discarded. When the final image is created, only these pixels make up the final image. This technique is crude, but is very fast and extremely effective at removing statistically outlying pixel values. It requires at least 3 images to be stacked, with a larger number of images providing a better result.

Sigma-Clip Stacking

Sigma-Clip stacking is also a process in which a series of images (after optionally being aligned) is examined pixel by pixel. Pixels with the same X and Y coordinates are sorted, and the mean (average value) and standard deviation are calculated. The deviation of each pixel in the stack from the average is then calculated. If the deviation is greater than **k** times the standard deviation, the pixel is rejected from the stack, the mean and standard deviation are recalculated, and the process repeats until no pixels are rejected. The value of **k** is selectable by the user, but typically a value of 3 is used. The pixels that remain after the statistical outlyers have been removed are then averaged together and are used to make up the final image. This technique is elegant, but time consuming. It works best with larger numbers of images, with a minimum of 5 images being required.

Choosing the value of k - While the default value is 3, any value greater than 1 can be used. Smaller values result in more pixels being discarded, and large values can result in the operation having no effect on the image at all.

Normalization

Normalization of sky brightness is necessary when using these techniques so that changes in the brightness of the background sky between images in the stack do not cause data to be discarded unnecessarily. High, thin clouds, light pollution, and other sources can cause the overall image brightness to change. This causes normally acceptable pixel values to appear as statistical outlyers and be discarded. In AIP4Win's Auto-Process|Deep-Sky tool, the user can select a region of the image which contains no stars or nebulosity, which the program will then monitor as each image is loaded (and optionally aligned). The average value of the pixels in this region, across all the images in the stack, is then adjusted by multiplying all the pixels in each image by a constant, calculated for that image, such that all the images will end up having the same average value for that region. It is not absolutely imperative that the region selected be free of stars or nebulosity, but it is recommended for best results.

Normalization is an option for Median stacking, and is required for Sigma-Clip stacking.