

# AIP4Win 2.0+ Feature Set

## Image File Formats

- Image load size limited only by memory available on host computer.
- Opens CCD images stored in FITS, 8-bit unsigned integer, 16-bit signed integer, 32-bit signed integer, 32-bit floating point, and 64-bit floating point. Opens color images stored in RGB-ordered FITS-compliant format.
- Saves images in fully compliant FITS format, 8-bit unsigned integer, 16-bit signed integer, 32-bit signed integer, 32-bit floating point, and 64-bit floating point. Stores color images in RGB-ordered compliant FITS format.
- Opens raw-format images from digital cameras, digital SLRs, and Bayer-array CCD cameras.
- Opens images stored in Santa Barbara Instrument Group, Starlight Xpress, and Cookbook file formats.
- Opens color and grayscale TIFF, JPEG, BMP, PNG, PCX, TGA, PICT, and many other standard graphics formats.
- Saves images, both color and grayscale, in TIFF, JPEG, BMP, PNG, PCX, TGA, PICT, and many other standard graphics formats.

## Internal Data Representation

- Internal data format is 32-bit IEEE floating-point.
- Data resolution equivalent to 8,400,00 gray levels.
- Positive and negative values treated equally.
- Dynamic range  $2 \times 10^{64}$  to 1; pixel values from  $10^{-32}$  to  $10^{+32}$ .
- 32-bit FITS read/write permits lossless saving/recall of all image data.
- Wide range of image math operations possible.

## Image Display Features

- Image display limited only by screen size/display card of host computer.
- Virtually unlimited Black/White display values; range from  $10^{-32}$  to  $10^{+32}$ .
- Precise setting of Black/White display values (seven decimal places).
- Automatic histogram speeds display of all image data.
- Full-color display for all images in color formats.
- Zoom settings from a minimum of 16.7% to a maximum of 1600%
- Seamless continuous precision zoom settings to 0.1%.
- Full scrolling at any zoom level to any part of image.
- Right-click auto-centering on any part of image.
- Auto-centered image remains centered through zooming to any size.
- Set image appearance using Black/White or Contrast/Brightness.
- Automatic one-click image display using Black/White endpoints.
- Automatic one-click Min/Max image display.
- Automatic one-click user-default Black/White pixel values.
- Optional display image as negative (white sky, black stars).
- Optional display image with desired gamma setting.
- Compensation available for gamma of computer monitor.
- User-setting for display-on-load defaults.
- User-setting for camera characteristics (pixel size, gain, readout noise).
- Right-click to display image statistics.

## Image Calibration Features

- Setup for auto-calibration supports basic, standard, and advanced calibration protocols.
- One-click auto-calibration using basic, standard, and advanced calibration; includes defect correction.
- Basic calibration performs dark-frame subtraction; single or multiple dark frames; averaged or median-combined.
- Standard calibration protocol performs dark-frame and flat-field correction; source frames constructions by user-selected averaging, median combine, or normalized median combine.
- Advanced calibration performs bias, dark-frame, flat-field, and defect correction using fixed bias or bias frame removal, exposure-time scalable or automatic dark-matching dark current subtraction, flat-field construction with averaged, median, or normalized median combine and auto-flat-dark subtraction, and defect correction using user-created defect correction map.
- Integrated Defect Correction included for point, cluster, and column defects in the CCD detector.
- Save master bias, dark, and flat-field frames for later use; use to build calibration library.
- Automatic calibration option with Multi-Image Auto Process Deep-Sky Tool, Multi-Image Photometry tool, and other file-list driven tools.
- Full manual calibration functions also available.

## Image Enhancement Features

Image enhancement functions can be applied to grayscale and color images.

- Pixel math operations include: add, subtract, multiply, divide, natural log, common log, exponential, square root,  $A-2.5\log(x)$  magnitude function.
- Pixel operations include invert, threshold, min-max (clip), offset correction.
- Brightness scaling with automatic input endpoint detection; linear, gamma, square root, cube root, square, gammalog, saw-tooth, and quantized transfer functions; output range selection, optional clip and invert; before and after histogram display; result preview window.
- Histogram shaping (output histogram specification) with automatic input endpoint detection; selection of exponential, Rayleigh, Gaussian, tangent, sine-wave, cosine, rooftop, hyperbolic, and equalized output histograms; output range selection, optional clip and invert; before and after histogram display; result preview window.
- Automated Fast Fourier Transform filtering; fully parameterized Butterworth high-pass, low-pass, band-pass, and band-stop options; automatic float and crop allow FFT filtering to be applied to images of any size.
- Full suite of convolution filters: Crispen, Sharpen, Smooth, Blur, Sobel, Prewitt, Laplacian, Gradient, Emboss (3x3), Emboss (5x5), Bas-relief, and Custom. Save and recall custom filter coefficients.
- Gaussian Blur Tool: blur radius range from 0.1 pixel to 40 pixels.
- Gaussian Unsharp Mask: mask radius range from 0.1 pixel to 40 pixels; user-adjustable contrast enhancement; optional parabolic, power-law, boxcar, triangular, and cosine blur functions.
- Wavelet Spatial Filter: uniquely customizable tool for sharpening, softening, and enhancing spatial frequency response. Optional background and background replacement. Enhances nebular detail without dark rings around stars. Save and recall filter profiles.
- Rank-Process Tool: provides rank-process for revealing hidden detail, multiplicative rank-process, minimum, maximum, and mean of median half.
- Our Deconvolution Tool acclaimed the best! Select point spread function as Gaussian PSF, measure from selected stars, or construct PSF from stars in target image. Deconvolution processes: Van Cittert (additive correction), Lucy-Richardson (fast), and Lucy-Richardson (slow). User selected iteration count; relaxation parameter; display iterations; ability to exit iteration on optimum appearance.
- Digital Development: nonlinear hyperbolic scaling combined with spatial filter optimizes deep-sky image nebular detail.
- Smooth Background: allows precise control of noise in the sky background by pixel-value threshold blending; with choice of Gaussian blend, median, or mean of median half blending functions.

- Sharpen High Values: sharpens bright image features using unsharp mask without increasing noise in sky background.
- Local Adaptive Sharpening: enhances edges and edge-like features adaptively by applying weak sharpening to areas that are already sharp and strong sharpening to areas that need additional sharpness.
- Extreme Value Operator: Adaptively softens uniform areas and enhances edge structure in areas with sharp edge structure.
- Noise Filter: Removes abnormally low-value and high-value pixels; removes impulse noise, filters cold pixels and hot pixels.
- Complete suite of classic morphological operators: includes contour mapping; Frei & Chen point, line, edge, and ripple detection; skeletonize and skeleton pruning; grayscale dilation, erosion, opening, and closing.
- Topographic Lighting Tool: creates visually convincing bas-relief images. Based on diffuse illumination model. Variable virtual-light elevation and azimuth.
- Constant Sigma Scaling: converts image containing Poisson noise and Gaussian readout noise into images with constant Gaussian deviate. Used with wavelet noise filters to reduce/eliminate image graininess.
- Wavelet Iterative Noise Filter: Applied to images with known CCD characteristics, able to remove noise while retaining all statistically significant image features without blurring fine detail. Results are amazing; requires detailed understanding of camera characteristics.
- Wavelet K-Sigma Noise Filter: Uses wavelet technology to reduce noise in images for which no accurate noise model exists.
- Fast Fourier Transform Tools: Forward FFT, Butterworth filter creation, Transform masking, and Inverse FFT provide powerful methods for processing images in frequency space.
- Stacking: you can stack both black and white and color images, with one or two stars, using image registration that includes image translation, rotation, and scaling. Optional calibration and brightness scaling also.

## Color Image Processing Features

- Color Image Tool: General-purpose tool for adjusting appearance of color images. Automatic white balance with customizable parameter settings; Cyan-Red, Magenta-Green, Yellow-Blue channel balance settings; Luminance gamma, saturation, and color smoothing; luminance and chrominance image previews; precision manual endpoint settings.
- Split Colors: Resolve color images into Red/Green/Blue (RGB) or Luminance/RGB channels for further processing of individual color channels.
- Color Calculator: A powerful tool for achieving accurate white-balance using images of solar-type G2V as celestial white-light standard. Allows compensation for differential atmospheric extinction of color channels.
- Process RGB: Allows speedy sub-pixel registration of red/green/blue image sets, and application of white-balance weights.
- Process CMY: Allows speedy sub-pixel registration of cyan/magenta/yellow image sets, and application of white-balance weights.
- Join Colors, RGB->Color and LRGB->Color. Two functions for quick color-combination experiments.
- Join Colors Tool: Combines RGB, LRGB, and LLRGB image sets into color. Automatic white balance with customizable parameter settings; Automatic white-balance using G2V star measurements, Luminance gamma, saturation, and color smoothing; luminance and chrominance image previews; precision manual endpoint settings.
- Color Effects Tool: A combination of powerful, useful, interesting, and novelty processes for processing color images. Change saturation, color balance, hue rotation angle.
- False Color Image: Transforms any image – grayscale or color – into brilliant colors. Use to enhance subtle detail, create eye-catching displays.
- Bayer Array Tools: A full suite of functions for converting RAW, CRW, NEF, and Bayer-array images from astronomical CCD cameras into color images. Output formats include full-size color, half-size color, full-size RGB color channels, half-size RGB color channels, and grayscale. Options for camera

white balance, user-set white balance, or automatic white balance; color smoothing, gamma curve, and saturation.

- Convert Color to Bayer: Transforms a color image into an RGGB grayscale Bayer-array image.

## **Image Transform Features**

- Flip and Flop: reflect image left to right, top to bottom.
- Translate, Rotate, Scale: gives the user complete control over shifting, turning, and resizing an image with sub-pixel precision. Rotate around any point; shift by whole or fractional pixels; scaling from 50% to 200%.
- Resample: Resize by percentage from 10% to 1000% (four decimal-place precision); or by pixel dimensions of resized image. Preserve aspect ratio or anamorphic scaling to square pixels.
- Float: Add pixel around the edge of an image.
- Crop: Clip the edges off an image. Use freehand mouse, or by pixel count and offsets.
- Center Planet: Precision centering for planet images; centering to 0.1 pixels.
- Rotate 90 or 180 degrees: Fast algorithms for turning images.

## **Image Editing Features**

- Copy current image (preserves data for experimenting).
- Copy image to Windows clipboard; paste image from Windows clipboard.
- Change pixel values one pixel at a time or by selected region (Pixel Pusher).
- Gradient correction using Plane, Hot Spot, or Rubber Sheet model.
- Automatic blending/patching over defects (Patch Tool).
- Automatic blending/patching over blooming trails (Patch Tool).
- Automatic repair/replacement of defective star images (Fat Star Fixer Tool).
- Automatic correction of well-behaved gradients (Rolling Pin Tool).
- Automatic correction of complex and involved gradients (Sky Background Fixer Tool).
- Add Gaussian noise (from  $10^6$  ADUs to  $10^{-6}$  ADUs root-mean-square noise).
- Synthetic image creation (complete toolkit for creating sky, stars, and deep-sky objects).
- Synthetic image simulation of CCD Poisson noise, dark current, dust donuts, and vignetting.
- Automatic correction of Venetian Blind Effect (occurs in certain CCD cameras).
- Edit FITS header; full line-edit tools. Critical/mandatory lines always protected.

## **Photometry, Astrometry, and Image Measurement Features**

- Statistics: Right-click on any image and see complete properties of the image; size, bytes of data, camera type, pixel sizes, display characteristics, status, and image-processing history. Statistical properties include minimum, mean, median, maximum, average deviation, standard deviation, and skew.
- Histogram: Displays a histogram for the image; mouse-over readout provides pixel value and pixel percentiles. Logarithmic scale shows dynamic range from 1 to 100,000 pixels.
- Magnifying Glass: Takes a detailed look at the image; mouse-driven freedom to explore the entire image. Magnifies 200% to 1600%.
- Pixel Tool: Instant readouts from any mouse-selected region of the image; optional choice of round, rectangular, and fixed-size round and square annuli. Output: location of selected region, minimum, mean, maximum, median, mean of median half, variance, and standard deviation. Click to save results in the Data Log.
- Star Image Tool: This special tool finds the precise location, size, and range of pixel values in any star image. It graphs the profile of the star image and determines the star's exact departure from perfect roundness.
- Distance Tool: Determines the distance and angle between any two star images. Measure the separation distance and position angle of double stars or the rhythmic shuffle of satellites as they orbit their planet; this is your yardstick for the heavens.

- Profile Tool: Swipe the mouse between any two points and view a profile cross-section plot of pixel values on a line between the two points. Auto-ranging or plot between current Black/White settings.
- Astrometry: Determines celestial coordinates for objects using other stars in the image as reference stars. Typical results better than 1 second of arc. Used by amateur astronomers to measure coordinates of supernovae, newly discovered asteroids, and to locate and identify variable stars. Astrometry is an essential tool used by professional astronomers.
- Single-Star Photometry Tool: Measures the brightness of star images. Reads starlight in a central opening and estimates sky background light through an annulus (donut) surrounding the star image. Provides all information needed for accurate scientific measurement of stellar magnitude; widely used by amateur astronomers and variable star observers.
- Single Image Photometry Tool: Measures the differences between star images for precise tracking of stars and asteroids that vary in brightness. Measures one variable star and multiple non-variable stars for comparison. Very accurate results: precise enough to see transiting exoplanets that occult only 1% of a star's light.
- Multi-Image Photometry Tool: Performs differential photometry (like the Single Image Photometry Tool) on a series of images to show magnitude changes over minute or hours. Automates lengthy scientific measurements; used by serious amateur astronomers and variable star observers to monitor variable stars, novae, supernovae, and asteroid brightness.
- Extractive Photometry Tool: Automatically measures the raw instrumental magnitude of every star in a CCD image. This is a tool for serious amateur astronomers who wish to obtain data such as the H-R (color-magnitude) diagram from images taken through different wavelength regions.
- Spectroscopy: Converts a two-dimensional spectrum such as might be obtained through a prism or diffraction grating into background-subtracted spectrum data. For amateur astronomers who wish to explore stellar classification.

### **Utilities for CCD Imaging and Image-Processing**

- Characterize CCD Camera Tool: provides a complete, easy-to-use module for determining the gain, readout noise, and linearity of an astronomical CCD camera.
- CCD Calculator computes field of view and resolution for all standard CCD and digital cameras.
- Julian Day Calculator converts any date into Julian Day number used by variable star observers.
- SNR Calculator models the performance of CCD cameras based on exposure time, dark current, flat-fields, and number of images stacked. Allows imagers to optimize use of dark-time hours.
- AIP4Win Customize sets important program default values.
- The Set Directories Tool sets the default locations for raw images, calibration frames, and astrometric catalogs.