CCDStack
Software Tools
Visualization & Control
for optimal images
Image Stack & Pixel Stacks

- Image Stack
  - Three dimensional array:
    - $X, Y = \text{width, height}$
    - $Z = \text{frame number}$

- Most Data Reject Methods use $Z$ dimension
  - At each $X,Y$ the $Z$ axis is a “pixel stack”
  - There are as many pixel stacks as pixels in a single image
  - Neighboring pixels have no direct effect on rejections
Pixel Stack Simple Mean

\[ P = \text{Sum}[P_1 + P_2 + \ldots] \div nP \]

Where:
\[ P = \text{result pixel value} \]
\[ P_1 = \text{pixel in image 1} \]
\[ P_2 = \text{pixel in image 2} \]
\[ \ldots \]
\[ nP = \text{number of pixel in pixel stack} \]
\[ = \text{number of images} \]
CCDStack Pixel Stack Mean

\[ P = \frac{\text{Sum}[P_1 w_1 r_1 + P_2 w_2 r_2 + \ldots]}{(w_1 r_1 + w_2 r_2 + \ldots)} \]

Where:
\( P \) = result pixel value

\( P_1 \) = pixel in image 1
\( w_1 \) = image 1 weight
\( r_1 = 0 \) if \( P_1 \) is rejected otherwise \( r_1 = 1 \)

\( P_2 \) = pixel in image 2
\( w_2 \) = image 2 weight
\( r_2 = 0 \) if \( P_2 \) is rejected otherwise \( r_2 = 1 \)

\( \ldots \)
Rejected Data & Missing values

- **Rejected Data**
  - Rejected pixel is tagged via separate binary array
  - Rejected pixel retains original value
  - Pixels can be un-rejected

- **Missing Value**
  - Assigned to pixels that have no real value
  - Missing value is permanent unless the pixel is overwritten.
  - Missing Values are always rejected
  - MissingValue constant = -33,333 ADU
Image Preparation for Data Rejection

- **Calibration**
  - Good practice to always calibrate
  - However it is not necessary

- **Registration**
  - Alignment accuracy is critical for good Data Rejection and Combine
  - New: Optional star pattern alignment plug-in: CCDIS/p
  - Resampling algorithm affects Data Rejection
  - Nearest Neighbor preserves pixels intact with no contamination
  - Other methods can smear or ring
  - Recommend Nearest Neighbor unless images are significantly undersampled or short stack or other imperative

- **Normalization**
  - Critical for good Data Rejection
  - Obvious symptoms of error
  - Re-normalization is OK (weights are adjusted accordingly)
Registration Resample Methods

- **Nearest Neighbor**
  - Preserves noise statistics
  - Prevents hold/cold pixel contamination
  - Promotes superior data rejection
  - Not advised for short or undersampled stacks
  - Very fast
  - Blink looks funny but combined image is good

- **Bi-linear**
  - Fast
  - Can preserve sharpness without ringing
  - Best for shift only (not so good for rotation or scaling)

- **Bi-Cubic**
  - Smooth (not necessarily a good thing)
  - Good for rotation or scaling (better than bi-linear)

- **Other Methods**
  - Slow
  - Subject to ringing (Fourier effects)
  - Preserves sharpness (Lanczos/sinc shaper than original)
Clip Min/Max

- Blend of Mean and Median
- Robust
- Best on large stacks (>12 frames)
- Use conservative parms
- Min & Max do not need to be the same (Max does most of the work)
STD = sqrt((P1-a)^2 + (P1-a)^2 + ...)

- Where:
  - P1 = pixel 1 ADU
  - P2 = pixel 2 ADU ...
  - a = mean of all pixels (P1 thru Pn)

- Not robust on small stacks
- Slow for large stacks
- Difficult to know appropriate factor (varies with stack size)
- Handles disparate PSF well
Poisson noise = square-root(signal) measured in electrons
Robust on any size stack (as few as 2 images)
Tends to rejects the least number of natural pixels while detecting outliers.
Susceptible to strange star effects for disparate PSF (limit number of iterations to minimize this effect).
Should use accurate GAIN and ReadNoise (Camera Manager)
Data Rejection Techniques

- Verify Rejections over All Images
  - Blink (use info rectangle) – look for over or under rejection
  - Renormalize if too unbalanced (multiple normalization is OK)
Special Treatment for Outliers

- Special Treatment for Bad Outliers (airplane, etc.)
  - Draw rectangle over the area
  - Apply strong rejection to that area in that image (restrict to selection; apply to this)
Experiment!

- Combine image without leaving Data Reject form
  - Combined image is automatically not included, so it has no effect on subsequent rejections or combines.
  - Examine combine and re-Reject if necessary.
This concludes the CCDStack Data Rejection Workshop

Thank You!