National Optical Astronomy Observatory

NEWFIRM Data Handling System

Quick Look Functionality

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Introduction

The primary function of the NEWFIRM quick look software is to perform simple quality assessment functions in order to verify that good data is being taken, i.e. that

- The instrument is functioning normally.
- The telescope is functioning normally.
- The observing conditions are acceptable.

The essential functions of the quick look software will normally be performed automatically as or immediately after the data is read out. However the analysis and reporting functions need not keep up with every frame. Sampling at some rate set by the system and software constraints is acceptable.

A suite of toolkit programs will provide other functionality, enabling observers to interact with the data and to perform a more detailed or non-standard quick-look analysis after the data is taken.

Data Quality Assessment Functions

The required data quality assessment functions can be roughly divided into four groups: automated real time display of the "calibrated" images, automated real time quality assessment measurements, automated post readout quality assessment measurements, and post readout observer interaction with the data. Examples of all four types of quality assessment functions are listed below.

Automated real time display of image data (RTD)

- Do minimal image "calibrations".
- Display the "calibrated" image data .
- Other

Automated real time data quality assessment (RTDQA)

- Compute background statistics for displayed "calibrated" image.
- Display and record computed background statistics.
- Other

Automated post readout data quality assessment (PRDQA)

- Compute background and PSF statistics for raw image.
- Record background and PSF statistics in image header.
- Display background and PSF statistics graphically.
- Log background and PSF statistics separately from image header.

- Archive image.
- Other

Post readout or post observing sequence observer toolkit (PPTK)

- Depends on type of observation

In some cases it may be useful to consider automating the post readout or post observing sequence operations normally done by the observer. For example it may be possible to automate the process of determining the best focus from focus observations.

In all cases it must be possible for the observer to disable the automated functions.

Required Software Modules

The required software modules are briefly described below.

Automated Real Time Display and Data Quality Assessment

The real time display (RTD) will perform a simple image "calibration" and display the "calibrated" images as they are being taken. The real time data quality assessment modules (RTQA) will make data quality assessment measurements on the "calibrated" images as the data is taken.

The calibration operations will be used only to provide a cleaner image for quick-look image display and data quality assessment. Calibrated images will not be saved permanently on disk or archived.

The RTQA measurements will be displayed in various ways for observer evaluation and logged / archived for data quality monitoring purposes. In normal observing mode the RTD and RTQA functions will be enabled. In setup and calibration mode it may be desirable to disable one or more of these functions and examine the data manually after an exposure or exposure sequence terminates.

The RTD and RTQA functions must be able to keep pace with a typical observing cadence of 1 image every 1 to 5 minutes. For faster observing cadences it will be adequate to process every Nth image where N is set by system and software constraints.

The RTD and RTQA functions will be enabled or disabled using a simple user interface. The RTD and RTQA image processing cadence will be specified from the same user interface.

User interface facilities will be provided for editing the RT image calibration options, the image display options, and the quality assessment computation and display options.

The real time calibration functions will be minimal and consist of background subtraction and flat field division only. Flat fielding will normally be performed only on object images, not on zeros, darks, flats, etc. The flat field may be a preexisting calibration library flat or a flat specified by the user. The background image will normally be an unprocessed sky facsimile image taken with the same filter and exposure time as the observation.

The RTQA measurements will consist of computing at minimum an estimate of the mean and standard deviation of the calibrated image pixels in some observer specified region of the IR imager, and displaying the results in graphical and text form for the observer.

Initial specifications for the RTD and RTQA software components are given below. Unless otherwise specified the benchmarks listed below were run on Vmware a 500 MHz Pentium with 782 RAM running RH 6.1, Linux kernel 2.2.12, with all reads and writes from and to a local SCSI disk.

Real Time Image Calibration

Purpose

- Monitor observing conditions.
- Visually detect fainter objects.
- Other

Function

- Subtract background image.
- Divide by flat field.
- Other

RTD image calibration parameters (observer controlled)

- Specify calibration directory path, default = "TBD".
- Enable image calibration, default = "yes".
- Enable background subtraction, default = "yes".
- Specify background subtraction options, default = "none".
    - None
    - Previously observed image (filter matters)
    - User specified background image (filter may or may not matter)
    - Other
- Enable flat field division, default = "yes".
- Specify flat field correction option, default = "none".
    - None
    - Default reference flat field image (filter matters)
    - User specified flat field image (filter may or may not matter)

- Specify minimum replace value for divide by zero, default = "1".
- Other (TBD)

RTD calibration status report

- Verify existence of user selected background image.
- Verify existence of user selected flat field image.
- Provide error message if calibration fails.

Benchmarks (reality checks on Vmware machine)

- Time to read 3 real 4k x 4k fits images from disk, compute the calibrated image with divide by zero check, and write a 4k x 4k real image to disk is
    - 9.1 CPU seconds, 29 real seconds
- Time to compute previous calibrated 4k x 4k image in memory is
    - 0.94 CPU seconds, 2.0 real seconds

Notes

- How automated is automated? If user decides to specify a background image which changes frequently one cannot totally automate this procedure.
- May need to enable / disable filter check on user specified background or flat field images.
- May need to reinitialize previous background image option when a new observing sequence starts.

Real Time Calibrated Image Display

Purpose

- Monitor instrument health (IR imagers).
- Monitor telescope health (positioning, focus).
- Monitor observing conditions (sky background).

Function

- Display calibrated image.
- Display raw image as well?

RTD calibrated image display parameters (observer controlled)

- Specify image display cadence, default = "1".
- Specify image display node, default ="".

- Specify frame buffer size, default ="imt4096".
- Specify frame buffer configuration, default = "1 2 3 4".
- Specify default display frame, default = "1".
- Specify image extensions to display, default="1 2 3 4".
- Specify calibration directory path, default = "TBD".
- Specify image bad pixel mask, default = "TDB".
    - None
    - Default
    - User specified
- Specify display command path, default = "TBD".
- Specify intensity scaling parameters, default = "TBD".
    - Automatically compute z1 and z2.
    - Specify z1 and z2.
    - Use precomputed z1 and z2.
    - Other
- Specify % image read out before display begins, default = "100".
    - Parameter is probably not required due to rapid readout rate.
- Specify whether or not to postpone image display until readout completes, default =”yes”.
    - Parameter is probably not required due to rapid readout rate.
- Other

RTD image display status report

- Generate and display any display procedure error.

Benchmarks (reality checks with Vmware)

- Time to read a 4k by 4k real image, compute the scaling factors, map the data pixels into 8 bit display pixels, and load the mapped pixels into a 4k x 4k frame buffer is
    - 8 CPU seconds, 10 real seconds.
- Time to read 4 2k x 2k real images from an MEF file, compute the scaling factors, map the data pixels into 8 bit display pixels, and load the mapped pixels into the display is
    - 6 CPU seconds, 13 real seconds.

Notes

- This function can be completely automated.
- Display the raw as well as differenced image?
- Is it reasonable to consider precomputing some image statistics in the instrument software or is the overhead too high? Doing this could aid RT display timings .

Real Time Calibration Image Statistics Computation

Purpose

- Monitor observing conditions.

Function

- Compute and record calibrated image background statistics.

RT calibrated image statistics computation parameters (some fixed, some observer controlled)

- Specify calibration directory path, default = "TBD".
- Specify image bad pixel mask, default = "TDB".
    - None
    - Default
    - User specified
- Enable statistics computation, default = "yes".
- Specify statistics box, default="TBD".
    - Whole image
    - Fixed section
    - An image extension and section set by observer
    - An image display marker positioned by the observer
- Specify maximum number of iterations, default="TBD".
- Specify lower good pixel value, default="TBD".
- Specify upper good pixel value, default="TDB".
- Specify lower clipping factor, default="TBD".
- Specify upper clipping factor, default="TBD".
- Specify histogram binning parameters, default="TBD".

- Specify output statistics log path, default = "TBD".

RTD calibrated image statistics

- Compute mean background level.
- Compute standard deviation around mean.
- Compute minimum background value.
- Compute maximum background value.
- Compute number of good data points.
- Compute histogram of good points.
- Other

RTD calibrated image statistics status report

- Add computed point to main user interface display (user alert).
- Add computed point to graphical display which includes:
    - Histogram of current calibrated image statistics .
    - Strip chart of previously computed calibrated image sigmas.
    - Strip chart of previously computed calibrated image levels.
- Specify the plotting parameters
    - Specify the histogram plot windowing parameters.
    - Specify the strip plot windowing parameters.
- Other
- Add computed point to graphical table.
- Add computed point to calibrated image statistics log file.
- Generate a warning in main user interface if statistics change too much from one image to the next.
    - Specify how much change is too much.

Benchmarks (reality checks on Vmware)

- Time to read a 4k x 4k real image and compute a single pass mean, sigma, min, max, and number of points is
    - 2.6 CPU seconds, 3 real seconds.
- Time to read a 4kx4k real image and compute mean, sigma, min, max, and number of points using 3 sigma rejection and a maximum number of iterations of 20, and assuming image is held in memory is

- 16 CPU seconds, 18 real seconds

- The equivalent times for a 512 x 512 box in the middle of the image are
  - 1.9 CPU seconds, 4 real seconds.
  - 0.34 CPU seconds, 1 real second.

- Time to compute mean, sigma, min, max and number of points for a 4x4k real array in memory is
  - 15.5 CPU seconds, 16 real seconds.

- The equivalent numbers for a 512 x 512 pixel region near the center of the image are
  - 0.2 CPU seconds, 0.5 real seconds.

- Time to compute histogram, cumulative histogram, and estimate the quartile points for a 4k x 4k real image on disk is
  - 5.2 CPU seconds, 7 real seconds

- The previous test run in memory takes
  - 3 .5 real seconds.

Notes

- How automated is automated? This function is only truly automated if the statistics box and statistics computation parameters can be fixed.

- Use the bad pixel mask to screen out bad pixels? Yes as the mask can be a useful for doing statistics of large regions.

- Compute statistics in a fixed imager or permit user to change imagers? Should be able to change imager for real time quick-look quality assessment.

- Is it a good idea to permit the user to change the size and position of the statistics box? Yes for real time quick-look quality assessment as long as the box has a minimum size.

- If the statistics computation parameters change then the new parameter values must be recorded in the log

Automated Post Readout Quality Assessment and Processing Modules

The automated post readout quality assessment and processing modules will compute quality assessment measurements on the raw images after readout is completed and prepare the raw images for the save the bits archive.

The primary function of the quality assessment modules is to monitor the observing conditions and record the quality assessment measurements. These measurements will be used by the quick reduce software, the full reduction pipeline, and the archive database to flag suspect data. The measurements will also be available at the telescope for observer evaluation.

In normal observing mode the PRQA functions will be enabled. In setup and calibration mode it may be desirable to disable one or more of these functions and examine the data manually after an exposure or exposure sequence terminates.

Ideally the PRQA measurements should be computed for every image, written in the individual image headers, and logged independently of the image. For a typical observing cadence of 1 image every 1 to 5 minutes this should not be a problem. For faster observing cadences it may be necessary to either queue the images until the quality assessment statistics are done before shipping them to the archive (Savethebits or alternative), or process every Nth image, and either extrapolate between quality assessment measurements, or leave them undefined for some images. For the sake of uniformity the first option is preferable to the latter.

The PRQA functions will be enabled or disabled from the main user interface. The PRQA image processing cadence (if other than 1 is required) will be specified from the main interface as well. Editing facilities will be provided for setting the quality assessment computations options.

The PPQA measurements will consist of 1) computing an estimate of the mean and standard deviation of the raw image pixels in some observer specified region of the imagers(s), and 2) computing PSF statistics including width, shape, and orientation of stellar object(s) for some region near the center of the field of view.

Initial specifications for these two functions are given below.

Automated Background Statistics Computation

Purpose

- Monitors background levels and noise for observers and later quick reduce software and pipeline reduce functions.
- Monitors background variations for observers and quick-reduce software and pipeline reduce functions.
- Provides a means of identifying deviant images after the fact.

Function

Either (if monitoring both instrument health and observing conditions)

- Compute background statistics for each imager.
- Write statistics to each image extension header.
- Graphically display statistics for all imagers .
- Log the statistics for all imagers independently of the image .

Or (if monitoring observing conditions)

- Do all the above but for one imager only in which case the measurements are treated as global quality assessment measurements and become part of the global header not part of the image extension header.

Parameters (some fixed, some observer controlled)

- Specify sub region for computing statistics.
    - Image sections (1 per imager, or 1 per detector...)
    - Image display markers (1 per imager, or 1 per detector...)
- Specify minimum good pixel value.
- Specify maximum good pixel value.
- Specify maximum number of rejection iterations.
- Specify lower sigma clipping factor.
- Specify upper sigma clipping factor.
- Specify minimum number of image pixels.
- Specify histogram binning parameter.

Computed statistics

- Compute mean of good pixels.
- Compute mean normalized by exposure time.
- Compute standard deviation of good pixels.
- Compute minimum good data value.
- Compute maximum good data value.
- Compute number of good data points.
- Compute histogram of good pixels.

Graphical display

- Plot histogram of good pixels.
- Plot of sigma vs. mean overlaid by predicted curve (per imager).
- Plot mean level (normalized by exposure time) vs. time of observation (filter specific).
- Generate warning if statistics vary too much from one frame to the next.

Benchmarks (reality checks with Vmware machine)

- See previous statistics estimates .

Notes

- How automated is automated? This function is only truly automated if the statistics box and statistics computation parameters can be fixed.

- Should the statistics computation parameters be fixed? For monitoring purpose probably.
- Is it possible that the saturation limits are significantly different from one imager to another?
- Should the size and position of the statistics boxes be allowed to vary? Probably as long there is a minimum box size.
- Only real point of interaction with the image display is optional but desirable use of markers to interactively define the statistics boxes.
- Function may be enabled even if RTD and RTQA is disabled.
- Function should be enabled if Savethebits is enabled
- Consider logging results only and not updating the image header? The preferred option is to update the header.
- If statistics are written to the header the appropriate keywords should be written to the header by the keyword translation module, initialized with INDEF values, and filled in later avoiding the possibility of FITS file updates.

Automated PSF Statistics Computation

Purpose

- Monitor telescope focus.
- Monitor telescope tracking.
- Monitor seeing changes.

Function

- Compute PSF statistics for image.
- Write PSF statistics to image headers.
- Graphically display PSF statistics.
- Log the PSF statistics independently of the image .

Parameters

- Specify how to find / select stars.
    - By hand? No not automated.
    - By catalog? No too complicated for this function as the technique depends on having a standard catalog on line locally and having a reasonably accurate WCS in the image header.
    - Automatically detect stars? Yes probably best approach.

- Specify image section for PSF statistics.
    - Image section (1 per image good enough...)
    - Image display marker (1 per image good enough...)
- Specify a detection threshold above background.
- Specify fitting box / radius for moments analysis.
- Specify minimum and maximum good pixel value.
- Specify minimum and maximum roundness criteria.
- Specify minimum and maximum sharpness criteria.
- Specify minimum number of good pixels.

Computed statistics

- Estimate FWHM.
- Estimate ellipticity.
- Estimate position angle.
- Estimate sharpness.
- Compute number of good pixels.
- Other

Graphical display

- Plot radial profile of brightest unsaturated star.
- Plot mean FWHM PSF vs. time of observation (filter specific?).
- Plot other statistics vs. time of observation (filter specific?).
- Generate warning if seeing measurement changes too much from frame to frame.

Benchmarks

- Time to detect bright objects in a 4k by 4k real image, do moments analysis and estimate x, y, intensity, number of pixels, FWHM ellipticity, position angle, and sharpness, and select objects with a range of magnitude, ellipticity, and sharpness is
    - 33 CPU seconds, 36 real seconds.
- Repeating the same function in a 512 x 512 pixel box near the center of the image.
    - 1.0 CPU seconds, 3 real seconds

Notes

- Given a little code optimization in the detect step and faster computers it may be possible to just compute PSF statistics for the whole image which opens up possibilities for more interesting quick-look PSF statistics tools.
- If a PSF box must be specified it should be set near the center of the FOV.
- Should the size and position of the PSF statistics box be allowed to vary? Probably as long there is a minimum box size.
- Only real point of interaction with the image display is optional but desirable use of markers to interactively define the PSF statistics boxes.
- Must accept that for some images there may be no stars bright enough to use for monitoring purposes.
- Should the PSF statistics computation parameters be fixed? Yes as much as possible for simplicity.
- Function may be enabled even if RTD and RTQA are disabled.
- Function should be enabled if archiving is enabled.
- Consider logging results and not updating the image header ? Only if PSF statistics computation cannot keep up with data taking.
- Can this function keep up with the data rate? Probably but if not interpolating between measurements may be ok?
- If statistics are written to the header the appropriate keywords can be written by the keyword translation module, initialized with INDEF values, and filled in later.

Archive (Save-the-Bits or Equivalent)

Function

- Send raw image to archive.
- Add checksum information.
- Add archive id.
- Other

Purpose

- Provides a safety net for the observers.
- Queues the raw data for the full pipeline processing.

Notes

Automated Post Observing Sequence Processing Modules

In some cases it may be desirable to automate certain post observing sequence operations normally performed manually by the observer. Examples of this kind of automation are: 1) automatically invoking a best focus determination task when a focus sequence terminates, 2) automatically invoking a dark of flat field image combining task when a dark or flat field observation sequence terminates. The logical conclusion of this approach is to invoke the quick-reduce software when an observing sequence terminates.

At present this level of automation is not a requirement but it is a useful possibility to keep in mind when designing the processing software.

The Observer's Toolkit

The observer's toolkit contains programs that are not run automatically by the DHS but are available for the observers to run at their own discretion after a readout or observing sequence is complete, any associated automated functions have completed, and the data is available on disk. These programs can be used to perform a more detailed or non-standard analysis on the raw data. Some of these programs also lend themselves to becoming part of an automated post readout or post observing sequence operation.

The primary toolkit quick look functions are listed below.

Image display and quick look analysis

Functions

- WCS readout
- Pixel value readout
- Line, column, and vector plots
- Histogram plots
- Contour and surface plots
- Radial profile plots
- Statistics in a box
- Quick-look PSF analysis
- Quick-look instrumental photometry

Programs

- IRAF Ximtool image display server
- IRAF [MSC]DISPLAY task
- IRAF [MSC]IMEXAMINE task

Image header examination

Functions

- List image headers.
- List selected image header parameters.

Programs

- IRAF IMHEADER task
- IRAF HSELECT task

Simple image statistics

Functions

- Compute statistics for a list of images.
- Same as above but through mask.

Programs

- IRAF [MSC]IMSTATISTICS
- IRAF MIMSTATISTICS task

Simple image arithmetic

Functions

- Add, subtract, multiply, and divide images.
- Do more complicated image operations.

Programs

- IRAF [MSC]IMARITH task
- IRAF IMFUNCTION task
- IRAF IMEXPR task

Image combining tasks

Functions

- Combine zeros, darks, flats into high signal-to-noise calibration images.
- Combine images of any kind to remove artifacts.

Programs

- IRAF IMCOMBINE task

Engineering / Setup utilities

Functions

- Estimate exposure times.
- Compute / check cross talk corrections.
- Estimate / check gain and readout noise.
- Compute / check bad pixel masks.
- Compute / check linearity corrections.
- Compute best focus position.
- Examine bit statistics.
- Estimate seeing characteristics.
- Other

Programs

- IRAF CCDTIME task (needs instrument specific info to be useful)
- IRAF XTALKCOR task (may be too MOSACI specific)
- IRAF [MSC]FINDGAIN task
- IRAF CCDMASK task plus scripts in XDWRED package
- IRAF [MSC]FOCUS and STARFOCUS tasks
- IRAF BITCOUNT task
- IRAF PSFMEASURE task

Notes

- No good utility for estimating linearity corrections.

Observing Setup Scenario

A detailed checkout / observing setup scenario illustrating how the instrument scientist / observer might interact with the quick-look software modules is shown below.

This list is not intended to be exhaustive.

Confirm Instrument Health: Zeros

Take a series of N zeros over the longest typical exposure period to check bias levels, readout noise values, bias level stability, bias patterns, and bias pattern stability.

RTD (as image is being readout)

Function

- Automatically display every (Nth) zero image as it is readout.

Purpose

- Immediate user feedback on background levels and patterns.

Notes

- Observer may disable this function.

RTQA (as image is being readout)

Function

- Automatically compute statistics for every (Nth) displayed image.
- Automatically plot statistics for every (Nth) displayed image.
- Automatically log and archive statistics for every (Nth) displayed image.

Purpose

- Provides immediate observer feedback on readout noise levels.
- Provides immediate observer feedback on background level stability.

Notes

- Observer may disable this function.

PRQA (after each raw image is readout)

Function

- Automatically compute statistics for each imager.
- Automatically write statistics information to raw image headers.
- Automatically plot raw image statistics.
- Automatically log and archive raw image statistics.
- Automatically archive raw images.

Purpose

- Provides for longer term monitoring of background levels and patterns.

- Provides for longer term monitoring of noise levels.

Notes

- Automated statistics computation should be enabled if automated archiving is enabled.

PPTK (after zero sequence is complete)

Function

- Combine the zeros into a single zero image.
- Display the combined zero image and check for background patterns.
- Display reference zero image and compare to current zero image.

Purpose

- Provides higher signal to noise estimate of background patterns.
- Provides comparison with reference zero.

Notes

- Examine images one at a time with display and IMEXAMINE?
- Run ZEROCOMBINE task to combine the zeros .
- Make ZEROCOMBINE an automated post sequence processing command?

Notes

- Zeros are normally taken for diagnostic purposes only.
- Zeros are not normally used in the calibration process.
- Is there any need to compute QA statistics as a function of channel? Probably not.
- Will some sort of bias correction be done in the controller? Maybe. Does this matter to the DHS? Maybe.

Confirm Instrument Health: Long Darks

Take a series of N darks over the longest typical observing exposure to check dark levels, dark patterns, and dark level stability.

RTD (as image is being readout)

Function

- Automatically display every (Nth) image as it is read out.
- Optionally subtract zero from every (Nth) image before displaying?

Purpose

- Provides immediate observer feedback on dark levels and patterns.

Notes

- Observer may disable this function.

RTQA (as image is being readout)

Function

- Automatically compute statistics for every (Nth) displayed image.
- Automatically plot the statistics for every (Nth) displayed image.
- Automatically log and archive statistics for every (Nth) displayed image.

Purpose

- Provides immediate observer feedback on dark level stability.

Notes

- Observer may disable this function.

PRQA (after raw image is readout)

Function

- Automatically compute the statistics for each imager.
- Automatically plot raw image statistics.
- Automatically write statistics info to raw image headers.
- Automatically log and archive raw image statistics.
- Automatically archive raw image.

Purpose

- Provides for longer term monitoring of dark levels and patterns.

Notes

- Automated statistics computation should be enabled if automated archiving is enabled.

PPTK (after series is complete)

Function

- Combine the darks into a single current dark image.
- Display the combined current dark image to look for dark patterns.

- Display a reference dark image and compare to current dark.
- Subtract zero from current dark and check dark levels.

Purpose

- Provides higher signal to noise estimate of dark pattern.
- Provides comparison with reference dark.

Notes

- Need a DARKCOMBINE function to combine the darks.
- May wish to make DARKCOMBINE an automated post sequence processing command.
- May wish to examine images one at a time with display and IMEXAMINE.

Notes

- These darks are taken for diagnostic purposes.
- These darks are not calibration darks.

Confirm Instrument Health: Gain And Readout Noise Check With Zeros and Flats

Set filter and take 2 single-coadd flats and 2 single-coadd zeros in order to check nominal gain (and readout noise) values.

RTD (as image is being readout)

Function

- Automatically display every (Nth) image.

Purpose

- Check that flats and zeros look normal.

Notes

- Observer may disable this function.

RTQA (as image is being readout)

Function

- Automatically compute statistics for every (Nth) displayed image.
- Automatically plot the statistics for every (Nth) displayed image.
- Automatically log and archive every (Nth) displayed image statistics.

Purpose

- Not required for this procedure.

Notes

- Observer may disable this function.

PRQA (after image is readout)

Function

- Automatically compute the statistics for each imager.
- Automatically write statistics information to raw image headers..
- Automatically plot statistics information.
- Automatically log and archive statistics information.
- Automatically archive raw images.

Purpose

- Precomputes some of the statistics required for gain estimation but not required for this procedure.

Notes

- Automatic statistics computation should be enabled if archiving is enabled.

PPTK (after data is taken)

Function

- Run simple gain and readout noise determination task.

Or

- Fetch or compute PRQA raw flat and zero statistics.
- Difference the two flats and compute statistics.
- Difference the two zeros and compute statistics.
- Estimate gain from statistics using Janesick's method.
- Estimate readout noise from statistics.

Purpose

- Provides estimate of gain and readout noise for each imager.
- Provides quick comparison with nominal engineering values.

Notes

- These are diagnostic darks and flats.
- These are not calibration darks and flats.
- Make test more robust by taking N pairs of flats and zeros and computing N gain and readout noise estimates.

  or

- Make test more sophisticated by taking N flats and N darks and estimating gain and readout noise from all possible pairs .
- Gain and readout noise may be better determined in the lab but checks are useful.

Confirm Instrument Health: Create/Check Bad Pixel Masks With Flats

Set filter and take 2 flats with different exposure times and 2 darks with the same exposure times as the flats in order to create initial bad pixel masks or check existing ones.

RTD (as image is being readout)

Function

- Automatically display every (Nth) image as it is read out.

Purpose

- Check that the flats and darks look ok.

Notes

- Observer may disable this function.

RTQA (as the image is being readout)

Function

- Automatically compute statistics for every (Nth) displayed image.
- Automatically plot the statistics for every (Nth) displayed image.
- Automatically log and archive the every (Nth) displayed image statistics separately .

Purpose

- Not required for this function.

Notes

- Observer may disable this function.

PRQA (after image is readout)

Function

- Automatically compute the statistics for each imager.
- Automatically write statistics information to raw image headers.
- Automatically log and archive statistics information.
- Automatically archive raw images.

Purpose

- Not required for this function

Notes

- Automated statistics computation should be enabled if archiving is enabled.
- Observer may disable this function.

PPTK (after data is taken)

Function

- Subtract darks from flats.
- Do linearity correction.
- Take ratio of two flats.
- Run simple bad pixel mask creation task on ratio.
- Compare to reference bad pixel mask.

Purpose

- Create or check the instrument bad pixel mask.

Notes

- These are diagnostic darks and flats.
- These are not calibration darks and flats.
- Are the bad pixel masks filter dependent? Probably not.
- How important are the non-linearity corrections to flats?

Confirm Instrument Health: Compute / Check Linearity Correction With Flats

Set filter and take series of N flats with a broad range of exposure levels and N darks with the same exposure times in order to determine the linearity corrections.

RTD (as image is being readout)

Function

- Automatically display every (Nth) image as it is read out.

Purpose

- Check that the flats and darks look ok.

Notes

- Observer may disable this function.

RTQA (as image is being readout)

Function

- Automatically compute statistics for every (Nth) displayed image.
- Automatically plot the statistics for every (Nth) displayed image.
- Optionally log and archive the statistics for every (Nth) image.

Purpose

- Not required for this function.

Notes

- Observer may disable this function.

PRQA (after image is readout)

Function

- Automatically compute the statistics for each imager.
- Automatically write statistics information to raw image headers.
- Automatically log and archive statistics information.
- Automatically archive raw images.

Purpose

- Not required for this function.

Notes

- Automatic statistics computation function should be enabled if archiving is enabled.

PPTK (after data is taken)

Function

- Run simple linearity coefficient determination program.

If correction function of intensity only then:

- Order data in increasing order of exposure time.
- Subtract appropriate darks from flats.
- Compute flat statistics and normalize to dynamic range of data.
- Compute predicted statistics based on exposure time.
- Fit curve to predicted versus observed statistics and determine correction coefficients.
- Compare to reference coefficients.

Else if correction function of intensity and position then

- Same as a above but for each pixel.

Purpose

- Generates a set of coefficients describing the linearity correction.
- Provides compare with a set of reference coefficients.

Notes

- These are diagnostic darks and flats.
- These are not calibration darks and flats.
- Can correction be determined more accurately in the lab? Don't know.
- Is this pixel as well as intensity dependent? Probably.
- There is no good IRAF tool for doing this at present.

Confirm Instrument Health: Take Calibration Darks

Take series of N darks for each exposure time and number of coadds combination represented in the observing program in order to provide calibration for the quick-reduce software and the archive pipeline.

RTD (as image is being readout)

Function

- Automatically display every (Nth) image as it is read out.

Purpose

- Provides immediate user feedback on dark levels.
- Provides dmmediate user feedback on dark patterns.

RTQA (as image is being readout)

Function

- Automatically compute statistics for every (Nth) displayed image.
- Automatically plot the statistics for every (Nth) displayed image.
- Automatically log and archive every (Nth) displayed image statistics.

Purpose

- Immediate user feedback on dark level stability.

PRQA (after raw image is readout)

Function

- Automatically compute the statistics for each imager.
- Automatically plot statistics.
- Automatically write statistics information to raw image headers.
- Automatically log and archive statistics independently of image.
- Automatically archive raw images.

Purpose

- Provides for longer term monitoring of dark levels and patterns.

PPTK (after series is complete)

Function

- Combine the darks into a single current dark image.
- Display the combined current dark image to look for dark patterns.

Purpose

- Provides higher signal to noise estimate of dark pattern.
- Provides more current darks to use with the quick reduce software.

Notes

- Need a DARKCOMBINE function combine individual darks.
- May wish to make DARKCOMBINE an automated post sequence processing command.

Notes

- Dome calibration flat exposure times must be considered part of the observing program exposure times when taking calibration darks.

Confirm Instrument Health: Take Calibration Dome / Projector Flats

Take a series of N flats for each filter exposure time, and number of coadds combinations represented in the observing program.

RTD (as image is being readout)

Function

- Automatically display every (Nth) image as it is read out.
- Automatically subtract best dark from image before displaying.

Purpose

- Provides immediate feedback on dome / projection flat levels.
- Provides immediate feedback on dome / projection flat patterns.

RTQA (as image is being readout)

Function

- Automatically compute statistics for every (Nth) displayed image.
- Automatically plot the statistics for every (Nth) displayed image.
- Automatically log and archive every (Nth) displayed image statistics.

Purpose

- Provides immediate user feedback on flats level stability.

PRQA (after raw image is readout)

Function

- Automatically compute the statistics for each imager
- Automatically plot statistics.
- Automatically write statistics information to raw image headers.
- Automatically log and archive raw image statistics.
- Automatically archive raw images.

Purpose

- Provides for longer term monitoring of flat levels.
- Provides for longer term monitoring of flat patterns.

PPTK (after each flat series is complete)

Function

- Dark and linearity correct the dome flats.
- Combine the flats into a single current dome flat image per filter.
- Display the combined current dome flat image to look for patterns.
- Display reference dome flats and compare to current dome flats..
- Display reference sky flats and compare to current dome flats

Purpose

- Create flats for on the fly calibration and quick reduce operations.
- Monitor flat field changes.

Notes

- Dome or projector flats may not be useful for flat fielding due to illumination problems so this step may not be required for calibration purposes.
- Linearity corrections may be necessary in order to get good flats.

Confirm Telescope Health: Zero Telescope Pointing

At present assume that this step is done by operator using object(s) with known position(s), the telescope control system, and TV guider, in such a manner than when telescope is pointed the requested position is approximately centered in the field of view of the imager.

Confirm Telescope Health: Position Field On Detector

Take a test exposure and check that the desired field is correctly centered before beginning an observation, and reposition if necessary.

RTD (as image is being readout)

Function

- Automatically subtract background from image before displaying in order to view faint objects.
- Automatically display every (Nth) image as it is read out.

Purpose

- Provides immediate user feedback on field positioning
- Provides WCS info for computing offsets.

RTQA (as image is being readout)

Function

- Automatically compute statistics for every (Nth) displayed image.
- Automatically plot the statistics for every (Nth) displayed image.
- Automatically log and archive every (Nth) displayed image statistics.

Purpose

- Not required for this function.

PRQA (after raw image is readout)

Function

- Automatically compute the statistics each imager.
- Automatically plot statistics.
- Automatically write statistics information to raw image headers.
- Automatically log and archive raw image statistics.
- Automatically archive raw images.

Purpose

- Not required for this function.

PPTK (after test image is complete)

- Take one more test image to check the repositioning.

Notes

- Might wish to delete or overwrite the test images and not archive them.

Confirm Telescope Health: Determine Best Focus

Set filter and take series of focus frames of bright object(s) at different focus settings in order to determine best focus.

RTD (as image is being readout)

Function

- Automatically display every (Nth) image as it is read out.

Purpose

- Immediate user feedback on best focus position.

RTQA (as image is being readout)

Function

- Automatically compute statistics for every (Nth) displayed image.
- Automatically plot the statistics for every (Nth) displayed image.
- Automatically log and archive every (Nth) displayed image statistics.

Purpose

- Not required for this function.

Notes

- Observer may disable this function.

PRQA (after raw image is readout)

Function

- Automatically compute the statistics for each imager.
- Automatically plot the statistics.
- Automatically write statistics information to raw image headers.
- Automatically log and archive statistics information.
- Automatically archive raw images.

Purpose

- Not required for this function.

PPTK (after each focus series is complete)

Function

Either

- Compute the FWHM of the PSF of the same object(s) at each focus position.
- Fit a curve to resulting set of points.
- Determine the best focus from curve minimum.

Or

- Use the focus determination task which does the above almost automatically.

Or

- Do simple visual interpolation using the image display.

Purpose

- Determine the best focus.

- Get an initial seeing estimate at the same time.

Notes

- Any reason to use region of interest cutouts for focus sequences?
- Is it necessary to focus in every filter or are predetermined focus offsets good enough?
- The telescope focus keywords should be recorded in the image headers.
- A focus determining task already exists.
- Although desirable it may be hard to completely automate this procedure without auxiliary telescope information.

Monitor Observing Conditions: Check For Sky Background Variations

As the data is taken display a background subtracted image and compute the background statistics so the observer can easily monitor the sky conditions.

RTD (as image is being readout)

Function

- Automatically display every (Nth) image as it is read out.
- Automatically subtract the background and divide by the flat before displaying every (Nth) image.

Purpose

- Provides immediate feedback on background levels.
- Provides immediate feedback on whether or not data is background limited.
- Provides immediate feedback on background illumination variations.

RTQA (as image is being readout)

Function

- Automatically compute statistics for every (Nth) displayed image.
- Automatically plot the statistics for every (Nth) displayed image.
- Automatically log and archive every (Nth) displayed image statistics.

Purpose

- Provides immediate feedback on background level changes.
- Provides immediate feedback on whether the data is background limited.

PRQA (after raw image is readout)

Function

- Automatically compute statistics for each imager.
- Automatically plot statistics for each imager.
- Automatically write statistics information to raw image headers.
- Automatically log and archive statistics info independently.
- Automatically archive raw images.

Purpose

- Provides for longer term monitoring of background levels and variations for the quick reduce software and pipeline.

PPTK (after raw image is readout)

Function

- Do more detailed examination of problem images with toolkit programs.

Purpose

- Enable observing strategy decisions.

Notes

- Best background image may be either the previous image or an image set by the user, e.g. a dark or sky.
- Background sky frames must be taken through the same filter.
- Flat fielding is optional but if enabled the flat should have the same filter id as the data .
- The first frame in sequence may not have a previous frame.
- May need to reset the differencing option when new observation begins, e.g. when the filter changes.

Monitor Observing Conditions: Check Seeing And Focus

As the data is taken estimate the size, shape, and orientation of the PSF in order to monitor and distinguish between seeing, focus, and tracking changes.

RTD (as image is being readout)

Function

- Automatically subtract background and divide by flat before displaying image.

- Automatically display every (Nth) image as it is read out.

Purpose

- Provides immediate feedback on PSF changes.

RTQA (as image is being readout)

Function

- Automatically compute statistics for every (Nth) displayed image.
- Automatically plot the statistics for every (Nth) displayed image.
- Automatically log and archive the displayed image statistics.

Purpose

- Provides immediate feedback on background level changes.
- Provides immediate feedback on whether the data is background limited.

PRQA (after raw image is readout)

Function

- Automatically detect bright stellar objects .
- Automatically do moment analysis of bright stellar PSFs.
- Automatically compute median of moment analysis statistics.
- Automatically write moments analysis results to image header.
- Automatically display moments analysis results.
- Automatically log and archive PSF statistics results.
- Automatically archive raw images.

Purpose

- Provides long term monitoring of seeing conditions.
- Alerts observer to focus or seeing changes.
- Alerts observer to tracking or guiding problems .

PPTK (after raw image is readout)

Function

- Do more detailed examination of problem images with toolkit programs.

Purpose

- Enable observing strategy decisions.

Notes

- The display of the difference image may not be very useful in this case.
- It is possible to drive this functions from a catalog if the image WCS is accurate enough for image location. However the overhead may be too high for the quick look software. This may be a quick reduce software function instead.