Calibration Frame Factory Application

Overview:

This Windows desktop application is a specialized sequencer app to Software Bisque TheSkyX Professional Edition imaging software for the creation of dark, bias and unrotated flat frame sets. The process replicates results that could be accomplished arduously through the Take Series feature, but organizes the set up as well as stores the images into a more logical and consistent library structure. Once set of calibration frames have been imaged, the app can also construct a reduction group map of those frames and update TheSky at initialization as a Full Calibration Library.

TheSky has the capability to perform full noise reduction on a light frame image. The user can apply reduction groups to individual images, to a folder of images, or automatically to each image when acquired. TheSky User Guide describes Image Reduction (starting on page 621). The feature requires the user to manually create lists of files in reduction groups, consisting of any number of bias, dark, and flat-field frames. As a rule, each group is appropriate for a specific exposure (darks and flats) and filter (flats). If the user is imaging at more than one or two exposures and filters, then the combinations proliferate rapidly. Manual configuration of these groups is slow and agonizingly tedious, especially with multiple dark exposure times. This utility fixes that by doing the configuration automatically, producing Image Calibration Groups that adhere to a specified naming convention. When imaging, the user can select the desired reduction group either manually in the Camera "Take Photo" window or programmatically using the ccdsoftCamera.ReductionGroupName method.
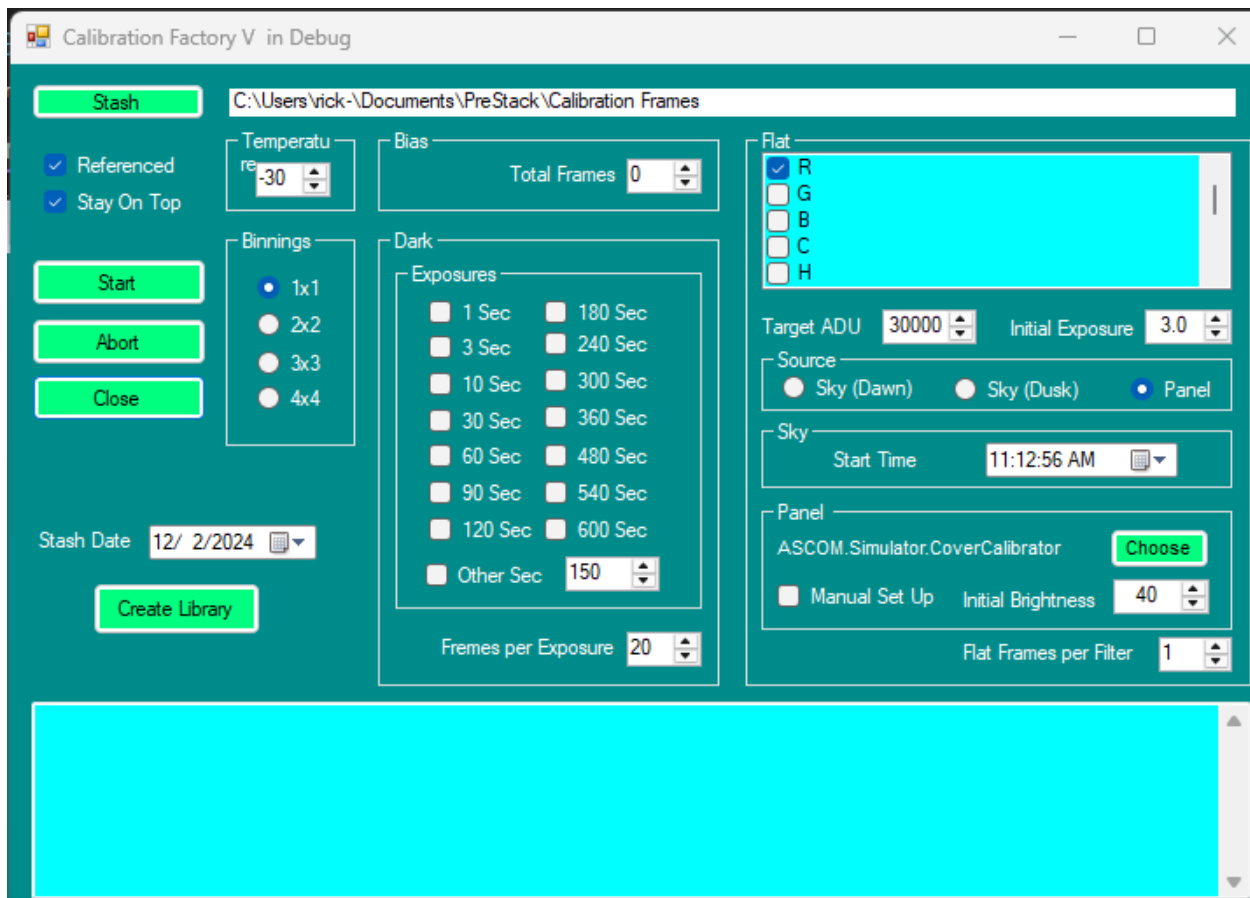
Configuration:

Stash: Sets base folder location for storing calibration frames. Default is <user>/Documents/PreStack.

Referenced: Determines if either a MyFlatField reference point has been created in TheSky to which the telescope should be pointed for imaging flat frames. See below.

Always on Top: Keeps the Calibration Factory window on top of all other windows while open.

Temperature: Determines the target CCD or CMOS camera array temperature for all calibration frames.

Binning: Determines the binning to be used for all calibration frames.

Bias:

Bias Frames: Determines the number of bias frames to be acquired.

Dark Frames:

Exposure: Determines exposure times for dark frames. "Other" can be used for exposure time that is not in list.

Frames per Exposure: Number of frames to be imaged for each dark exposure time.

Flat Frames:

Filter List (unlabeled): List of filters that are configured for TheSky. Select all filters for which flats are to be imaged.

Target ADU: Determines the average ADU desired for flat frames. Prior to imaging each filter, Calibration Frame Factory will attempt to adjust the brightness (panel) or exposure (sky) to produce an image whose average ADU is close to the Target ADU.

Initial Exposure: For panel flats, this value is the exposure time for all flats to which the panel brightness will be ADU-optimized.

Source: Determines the type of illumination to be used for flats, either sky flats (dawn/dusk) or panel (e.g. Altinak FlatMan).

Sky – Start Time: TBD

Panel – Choose: Select to set ASCOM Calibration device.

Panel – Manual Set Up: Select if panel requires manual intervention to position before taking flat images.

Panel – Initial Brightness: Set panel brightness level at which the ADU-optimizing brightness process will start.

Frames per Filter: Determines the number of flat frames that will be imaged for each filter. Note that sky flats may become either too bright (dawn) or too dim (dusk) whereupon imaging can automatically end without completing all flats or filters. This state occurs if the calculated exposure time for a given Target ADU exceeds 60 seconds or is less than 1 second.

Reference Point:

Flat Field Reference Point: If the user wishes to have Calibration Frame Factory point the telescope at a designated location for imaging flat frames, a reference point named "MyFlatField" must be created in

TheSky. To create a MyFlatField reference point, select Input->My Chart Objects->Add and Edit. Select Horizon (to enter Az/Alt coordinates). For sky flats, enter 0 for Az and 90 for Alt. For panel flats, enter panel coordinates, or slew telescope to point at panel and use telescope Az/Alt coordinates.   Then choose Reference Point for type and enter "MyFlatField" for label. Select OK and exit.

PreStack File Structure:

All frames are stored in a directory substructure whose base directory "PreStack" is created in the user's document folder. A subdirectory "Calibration_<date>" is created for each day that Calibration Frame Factory is run, where <date> is in the format MMMddyyy. See the diagram for the internal file organization. The calibration date root will contain three subfolders: Darks, Bias, Flats.

Within the "Darks" folder, the image library is separated into exposure subfolders (e.g. "60", "120", etc), At the next level down are separate binning subfolders (e.g. "1x1"," 2x2", etc). These binning subfolders contain subfolders for the date the dark was taken (e.g. "21Mar2016"). Within this lowest level are stored the respective dark image FITS files. The "Bias" subfolders are the same, with the exception that there are no exposure subfolders. All bias frames are taken with a 0.001 second exposure. This overall structure is created and/or verified upon launch.

Image files in the Flats folder are not divided into subdirectories. Flats filenames are set by filter, temperature and binning.

During each run, dark images that repeat (e.g. same binning, same exposure, same temperature) are distinguished by a sequence number prefix. However, if Calibration Frame Factory is run again on the same date, dark images taken with the same binning, same exposure, same temperature may be overwritten as the program does not check for identical sequence numbers.

Each dark image will be stored with the following filename format:

> "Dark.B<binning>.E<time in seconds>.T<temperature>.<sequence number>.FITS"

Each bias image will be stored with the following filename format:

> "Dark.B<binning>. T<temperature>.<sequence number>.FITS"

Reduction Group Generation

TheSkyX Image Calibration Library is organized into "Groups". Each Group is applied as a whole for an image noise reduction. Groups consist of sets of Bias Frames, Dark Frames, Dark Frames for Flats Only, and Flat Frames. During reduction, THESKY will combine the frames in each of these sets to produce master frame for that set. These master frames are then applied for noise reduction of light frames when a user selects the "Full Calibration" option for "Reduction" in the camera or autoguider set up window. The determination of which calibration library group is to be applied to a given image is dermined either manually or programmatically. Post imaging, the master frames from this Group will be applied to reduce the image (noise).
For each Group, the following rules apply:

1. All images to be reduced by a given Group are of the same binning, exposure, filter and temperature.
2. All reduction frames (bias, dark, flat) are taken at the same camera temperature as the images.
3. All reduction frames within each set (bias, dark, dark for flat, flat) have the same exposure, temperature, binning and filter, if applicable.
4. All Bias Frames are 0 seconds duration.
5. All Dark Frames are of the same exposure time as the images to be reduced
6. All Flat Frames are of the same filter as the images to be reduced.

7. All Dark Frames for Flats Only are of the same duration as the Flat Frames.

Once the user has manually created Image Calibration Library Groups and populated them with file-paths to the reduction frames, these lists are stored as a record in the TheSky AppSettings.ini file. This file with its Image Calibration Library definitions is loaded when TheSky is launched.

<u>Commands</u>

<u>Start</u>

The start command initiates image sequencing through TheSkyX as defined by the assorted configuration fields.

<u>Abort</u>

Ends all imaging.

<u>Close</u>

Closes application.

<u>Create Library</u>

This command takes a heap of bias, dark and flat frame files and sorts out all combinations of binning, temperature, exposure and filter. The user may image and name the FITS files as they please as the program extracts this information from the FITS header   The only requirement is that all bias, darks and flats images to be grouped reside in the same directory tree. The user is given the opportunity to select a specific binning and temperature as found in the heap.   The program then builds an exhaustive set of groups based on the following rules:

1. Flat files are separated into sets of the same filter (and appropriate temperature and binning).
2. Dark files are separated into sets of the same exposure (and appropriate temperature and binning).
3. Groups are created for each combination of a set of Flats (by filter) and set of Darks (by exposure).
4. For each group, the Dark Frames for Flats Only, is populated with a Dark set of the same exposure as the respective Flat set.
5. Every group gets all Bias files of appropriate temperature and binning.

Once the definition of these Groups is complete, a new record is formed and substituted for the existing record in the AppSettings.ini file.

Note that all FITS files in that directory tree will be surveyed for grouping so the directory tree should not contain functional duplicates, e.g. dark files of different dates.

Each group produced for the calibration library will have a name assigned according to the following convention:

B<b>_T<t>_E<e>_F<f>

Where

<i><b></i> = binning: "1X1", "2X2", etc
<i><t></i> = integer temperature in Centigrade: "x"
<i><e></i> = exposure in seconds: "e.eee"
<i><f></i> = filter name: "C", "R", "B", "V", etc

Examples

   "B1x1_T-20_E35.0_FC"
   "B2x2_T-10_E180.0_FRed"

Requirements:

Calibration Frame Factory is a Windows Forms executable, written for .NET 4.8.1 and TheSky64. The application runs as an uncertified, standalone application under Windows 10/11. If the library function is selected, the program creates and maintains a directory structure in the user's Documents directory called "PreStack" (default) which can get large as images are added, thus storage requirements depend on usage. This directory can be changed for image storage, but is required for configuration purposes.

Installation:

Download "CalFrameFactory64Buildxxx.zip"" from the GitHub directory at https://github.com/rrskybox/Darks-Knight/tree/master/Darks%20Knight/publish. Unzip and run "setup.exe". Upon completion, an application icon will have been added to the start menu under the category "TSX Toolkit" with the name "Calibration Frame Factory". This application can be pinned to the Start Menu if desired. In addition, TheSky64 must be run in Administer mode once in order to register its interface libraries.

Support:

This application was written for the public domain and as such is unsupported. The developer wishes you his best and hopes everything works out, but recommends learning Visual Basic (it's really not hard and the tools are free from Microsoft) if you find a problem or want to add features. The source is supplied as a Visual Studio 2022 project directory.

DarksKnight Directory Structure

```
                          ┌──────────┐
                          │ PreStack │
                          └────┬─────┘
              ┌────────────────┴────────────────┐
         ┌────┴─────┐                       ┌────┴─────┐
         │   Bias   │                       │  Darks   │
         └────┬─────┘                       └────┬─────┘
         ┌────┴─────┐                       ┌────┴─────┐
         │   BxB    │                       │   BxB    │
         │ (binning)│                       │ (binning)│
         └────┬─────┘                       └────┬─────┘
         ┌────┴─────┐                       ┌────┴─────┐
         │ ddMMMyyy │                       │   ddd    │
         │  (date)  │                       │(exposure)│
         └────┬─────┘                       └────┬─────┘
              │                             ┌────┴─────┐
              │                             │ ddMMMyyy │
              │                             │  (date)  │
              │                             └────┬─────┘
         ┌────┴───────┐                   ┌──────┴─────┐
         │ MasterBias-tt│                 │ MasterDark │
         │  (tt = °C)   │                 │  mm-dd-yy  │
         └────────────┘                   └────────────┘
```