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(http://neoastrosoft.com)

FrameSmooth

User guide

Version 2.0

2017

Contents:

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FRAMESMOOTH SOFTWARE LICENSE AGREEMENT

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If you have questions concerning the User License Agreement, or, if necessary, contact the group of FrameSmooth software developers for some reason – use the address information supplied with the FrameSmooth software, or visit the web site (http://neoastrosoft.com).

2. Common information

FrameSmooth software – cross-platform module for brightness equalization. It allows processing images with any formats. Module is based on using of inverse median filter for brightness equalization. Also it supports using of additional astronomical master-frames (Bias, Dark, DarkFlat and Flat).

Also the feature for converting images in fits format was added.

3. Minimal system requirements:

- **Windows** system from 7 (32, 64-bit) version or **UNIX** system (32, 64-bit);

- **Processor** frequency no less 1 Hz;

- **RAM** no less 2GB;

- Free space on the hard drive (taking into account the space for temporary files) no less 6GB.

4. Supported file formats

FrameSmooth in filter mode supports the following file types – *jpg, png, tiff, bmp, and gif* of 8 and 16 bits depth and *fits* files of different bits depth.

IMPORTANT! The file names and paths to them should not contain cyrillic characters.

5. Windows configuration

Recommended using the latest version of Java 8 (32-bit, 64-bit).

6. Linux configuration

6.1. Verify Java version

Recommended using the latest version of Java 8.

Verify Java version. Perform in the terminal the following:

```
java –version
```

If Java version is less than 8, install Java 8. Perform in the terminal the following:

```
sudo add-apt-repository ppa:webupd8team/java
sudo apt-get update
sudo apt-get install oracle-java8-installer
```

6.2. Compiler C & C++ update

5.2.1 Compiler C

Verify compiler C version. Perform in the terminal the following:

```
gcc –v
```

If compiler C version is less than 4.8, install gcc 4.8 or higher. Perform in the terminal the following:

```
sudo add-apt-repository ppa:ubuntu-toolchain-r/test
sudo apt-get update
sudo apt-get install gcc-4.8
sudo update-alternatives --remove-all gcc
sudo update-alternatives --install /usr/bin/gcc gcc /usr/bin/gcc-4.8 20
sudo update-alternatives --config gcc
```

5.2.2 Compiler C++

Verify compiler C++ version. Perform in the terminal the following:

```
g++ -v
```

If compiler C++ version is less than 4.8, install g++ 4.8 or higher. Perform in the terminal the following:

```
sudo add-apt-repository ppa:ubuntu-toolchain-r/test
                  sudo apt-get update
               sudo apt-get install g++-4.8
          sudo update-alternatives --remove-all g++
 sudo update-alternatives --install /usr/bin/g++ g++ /usr/bin/g++-4.8 20
             sudo update-alternatives --config g++
```

6.3. Set the permissions for all FrameSmooth modules

Set the required permissions (read/write) for the directory with all installed FrameSmooth modules. Perform in the terminal the following:

```
chmod -R 700 Path_to_FrameSmooth.jar
```

6.4.Installing libraries for graphical formats support

Libraries for graphical formats (*tiff, jpg, png, gif, bmp*) support are necessary for transformation graphical files to FITS format and for "*Brightness Equalization*" with files different graphical formats. For processing only FITS files by FrameSmooth software these libraries are **not necessary**.

Libraries for graphical formats support are available by the following links: tiff, jpg, png, gif и bmp. Full list of libraries for graphical formats support is available here.

To install libraries for graphical formats support download archive for required graphical format. Example for *tiff* format: extract downloaded archive ***tiff-4.0.4.tar.gz***, navigate to extracted folder ***tiff-4.0.4*** and perform in the terminal the following:

```
./configure
make
sudo make install
```

6.5. Installing ImageMagick library

ImageMagick-6.9.3-10 library is necessary for FrameSmooth software to process different graphical formats (*tiff, jpg, png, gif, bmp*).

To install ImageMagick library extract downloaded archive ***ImageMagick-6.9.3-10.tar.xz***, navigate to extracted folder ***ImageMagick-6.9.3-10*** and perform in the terminal the following:

```
./configure
make
sudo make install
sudo ldconfig /usr/local/lib
```

7. FrameSmooth software launch.

To launch FrameSmooth software you need to run ***FrameSmooth.jar*** file with help of Java 8.

In Linux, also possible to run FrameSmooth software via terminal:

```
java -jar Path_to_FrameSmooth.jar
```

8. Main window

Access to the program features can be provided through the main window of GUI (fig. 1).
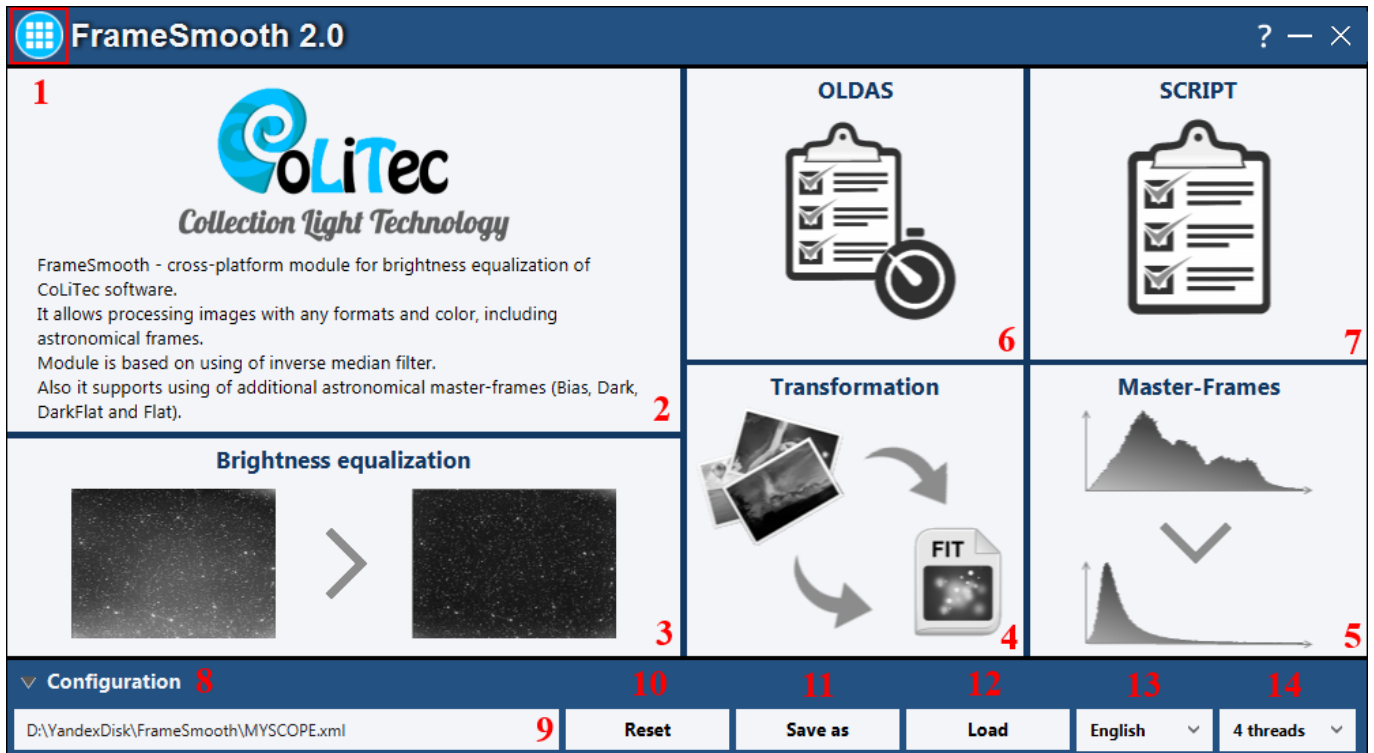

Fig. 1. Main window.

1 – Navigate to home page from processing mode;

2 – FrameSmooth software description with ability to visit official web site of CoLiTec project (http://neoastrosoft.com);

3 – Select brightness equalization mode (section 8);

4 – Select image transformation mode (section 9);

5 – Select mode for creation and using of master frames (section 10);

6 – Select OLDAS mode for the frames processing in real-time (section 11);

7 – Select SCRIPT mode for the frames processing with selected sequence of operations (section 12);

8 – Expanded configuration pane;

9 – Path to the active configuration file;

10 – Reset all settings to default;

11 – Save configuration file with new name;

12 – Load configuration file;

13 – Select interface language;

14 – Select threads count for processing.

9. Brightness equalization

Astronomical digital images may be divided into coarse-grained and fine-grained components. Each of these components has its own physical nature.

Coarse-grained components correspond to the illumination of the image during astronomical observations at full moon or at sunrise/sunset and cover large part of frame (Fig. 2a). Fine-grained components correspond to the images of stars, asteroids and comets. The size of fine-grained components usually takes $5 \div 10$ pixels and no more than $50 \div 60$ pixels.

Using of service frames for calibration of obtained images does not al-ways lead to desired result, for example, in case of parasitic illumination. Therefore it is necessary to consider ways of brightness equalization of image background.

Coarse-grained and fine-grained components of the digital image correspond to different harmonics in image spectrum (Fig. 2). Coarse-grained components of the image (Fig. 2b) correspond to low-frequency harmonics image spectrum (Fig. 2c), and fine-grained components (Fig. 2d) correspond to high-frequency harmonics.

Difference in spectrum of images of interest (stars, asteroids, comets) and image background (coarse-grained components of astronomical images) makes it possible to use image frequency filtering for increasing the signal-to-noise ratio or decreasing the dynamic range of the image background.

To remove coarse-grained components from the image it is advisable to use a high-pass filter that both attenuates low-frequency harmonics of the image spectrum and passes high-frequency harmonics. It is known that median filter with a certain window size may also perform functions of low pass filter. In this case high-pass filtering can be obtained by simple subtraction of the result of median filtering of the frame from initial frame.

In other words, difference in sizes of images of objects of interest (stars, asteroids, comets) and background (coarse-grained components of astronomical images) allows using image median filtering for coarse-grained components extraction. In this regard, described method has been called "inverse median filtering".
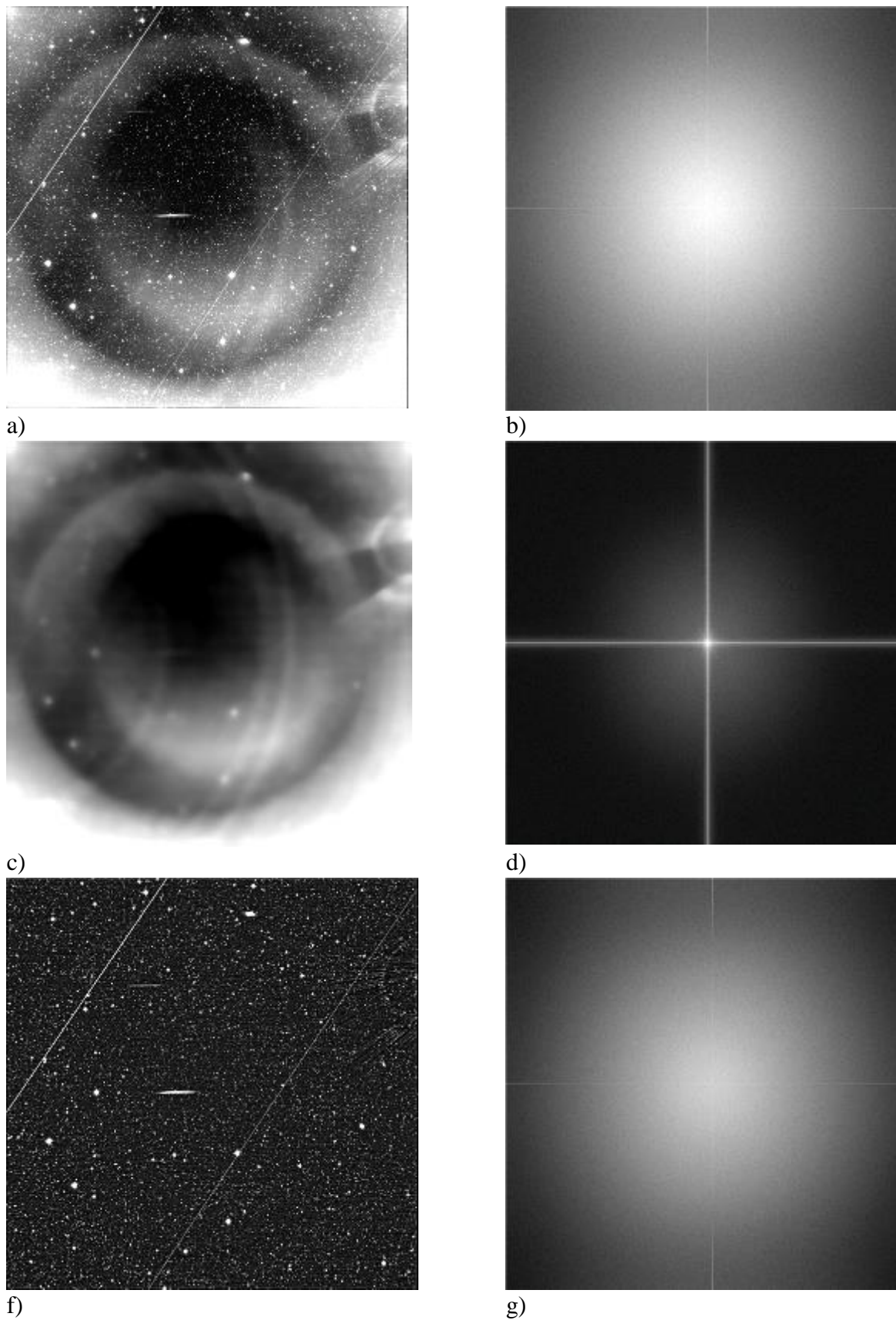
Fig. 1. a) Astronomical image. b) Spectrum absolute value of astronomical image. c) Coarse-grained component of astronomical image. d) Spectrum absolute value of coarse-grained component f) Fine-grained component of astronomical image. g) Spectrum absolute value of fine-grained component
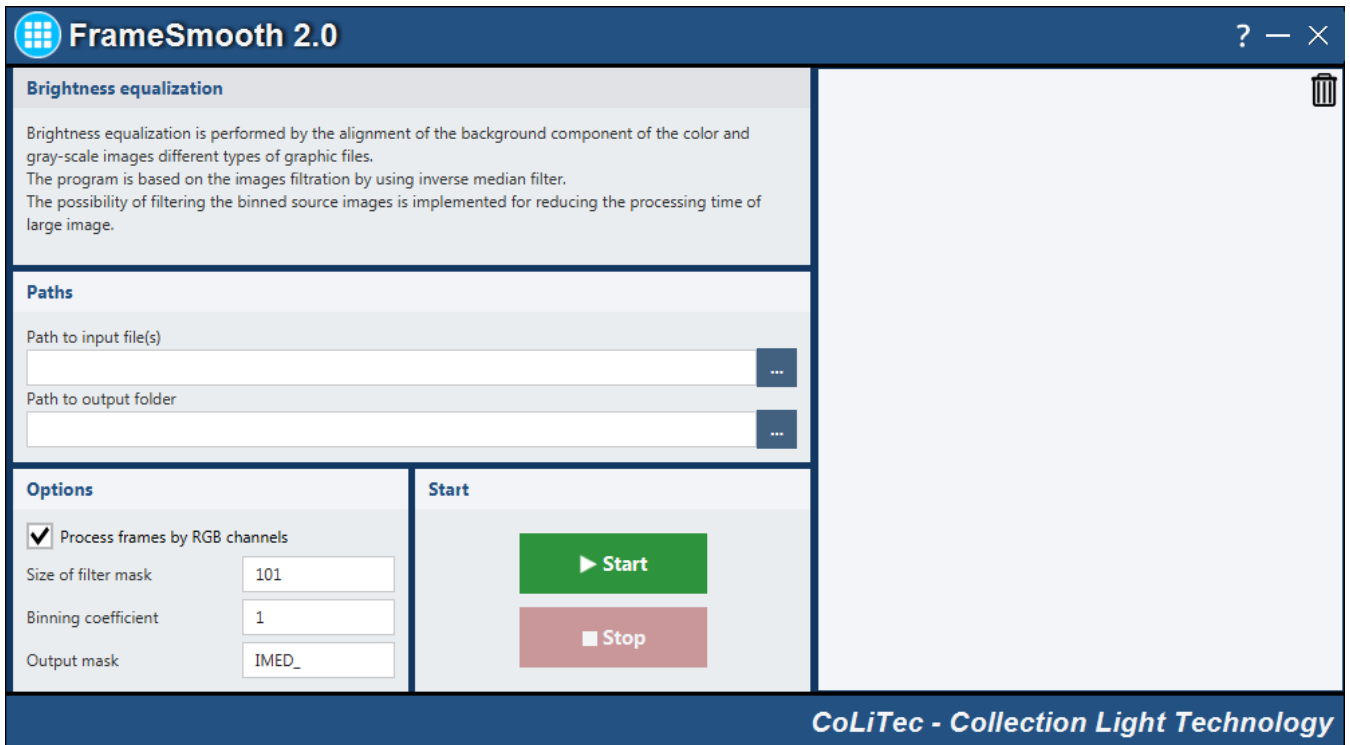
Fig. 3

1. In "***Paths***" pane following paths can be set:

- "*Path to input file(s)*" – path to the raw files.

- "*Path to output folder*" – path to the output folder of processed files.

2. In "***Options***" pane set modes:

- "*Process frames by RGB channels*" allows processing a color image by channels. It is not affect for filtering of gray images and fits-files;

- "*Size of filter mask*" width and height of a square median filter mask;

> *The recommended value of the inverse median filter mask size is determined by the expression:*
> $$w \geq \sqrt{3\pi}R,$$
> *where R – radius of the image of the brightest object by $2\hat{\sigma}_{noise}$ level of background;*
> $\hat{\sigma}_{noise}$ *– RMS evaluation of the background brightness.*

- "*Binning coefficient*" sets the binning coefficient. When using binning the median filtering is performed with binning image. The result of median filtering is de-binning and subtracted from the original image. The binning operation allows reducing memory usage and processing time of large images.

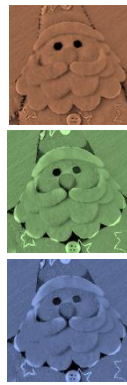- "*Output mask*" – mask for file names of the processed images.

Filtering the color image

with *"Process frames by RGB channels"* option:

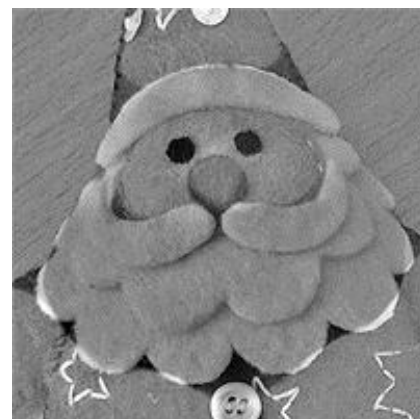| Original color image | Three channels of the original image | Three channels of the processed image | Processed color image |

Filtering color images

without *"Process frames by RGB channels"* option:

| Original color image | The gray image obtained from the original image | Processed gray image |

10.   Image transformation to FIT format

Fig. 4

1. In "***Paths***" pane following paths can be set:

- "*Path to input file(s)*" – path to the raw files.

- "*Path to output folder*" – path to the output folder of processed files.

2. In "***Options***" pane set transformation parameters:

- "*Do image inversion*" – activates the image inversion function during transformation.

- "*Make crop*" – activates the crop creation function. It defines by the coordinates of the upper left vertex, the width and height.

- Crop parameters can be set in "*X*", "*Y*", "*Width*" and "*Height*" fields.

11. Master-Frames creation and using

Functionality section for "manual (individual)" creation and using of the additional master-frames.

11.1. Master -frames creation

To create additional master-frames use the following tab:

"*MF creation*"

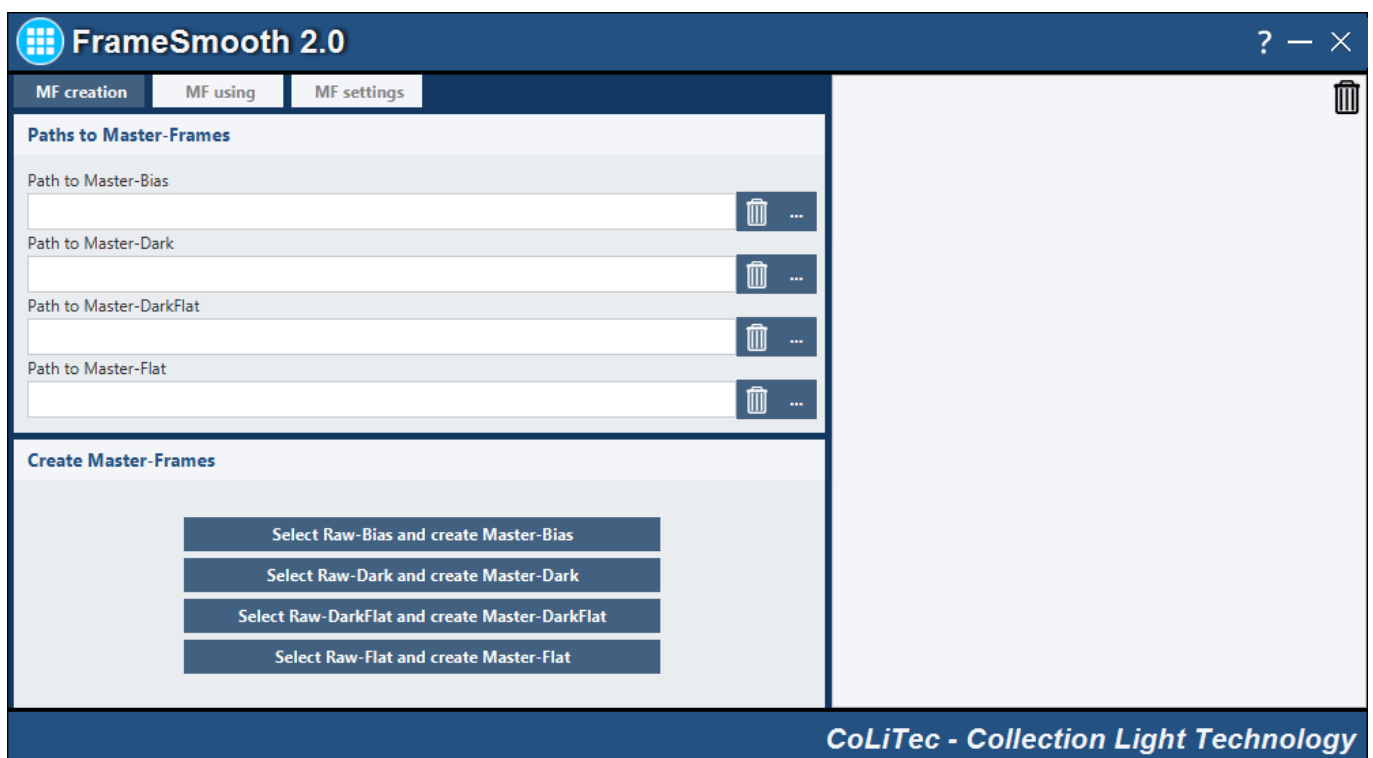*Fig. 5*

1. For creation the master-frame perform the following:

    1.1. Master-Bias – press "*Select Raw-Bias and create Master-Bias*" button.

    1.2. Master-Dark – press "*Select Raw-Bias and create Master-Dark*" button.

    1.3. Master-DarkFlat – press "*Select Raw-Bias and create Master-DarkFlat*" button.

    1.4. Master-Flat – press "*Select Raw-Bias and create Master-Flat*" button.

2. Paths of the created master-frames will be inserted to the appropriated fields:

    2.1. For Bias – "*Path to Master-Bias*".

    2.2. For Dark – "*Path to Master-Dark*".

    2.3. For DarkFlat – "*Path to Master-DarkFlat*".

    2.4. For Flat – "*Path to Master-Flat*".

3. If Master-Bias and Master-DarkFlat master-frames were created, they will be used for creation Master-Dark and Master-Flat master-frames. If necessary, you can select another Master-Bias and Master-DarkFlat.

4. If you want to create a Master-Dark and Master-Flat frames without Master-Bias and Master-DarkFlat frames, you should clean "*Path to Master-Bias*" and "*Path to Master-DarkFlat*" fields.

5. The mask for created master-frame can be set in "***MF settings***" section.

11.2.   Master-Frames using

To use additional master-frames select the following tab:
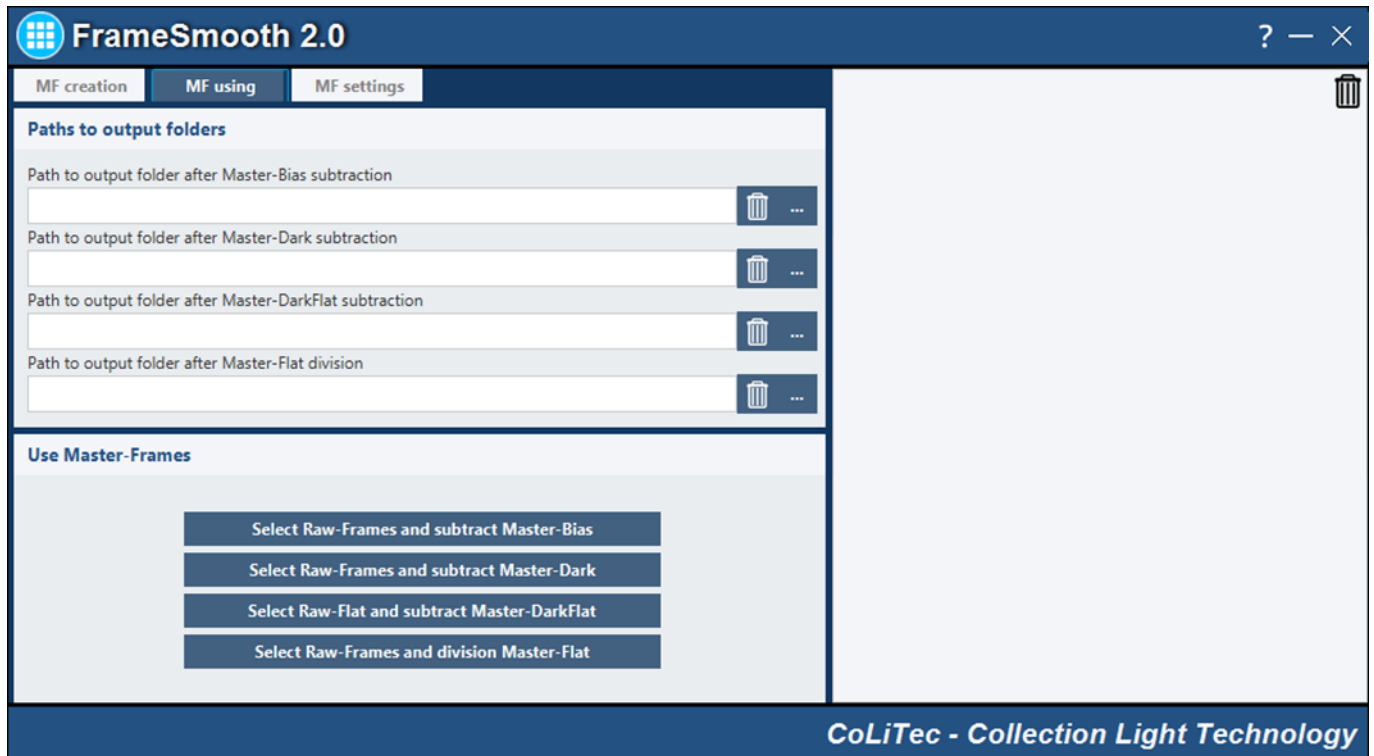
"MF using"

Fig. 6

1. For calibration raw (Light) frames the appropriate paths to the master-frames should be set in "***MF creation***" tab.

2. You should specify the output directory where will be saved Light-frames after using the appropriate master-frames.

3. In "*Use Master-Frames*" field to set type of the Light-frames processing: Subtract Master-Bias, Subtract Master-Dark, Subtract Master-DarkFlat or division on Master-Flat.

4. Rejection and division masks for the new names of Light-frames after the appropriate master-frame using can be set in the "***MF settings***" section.
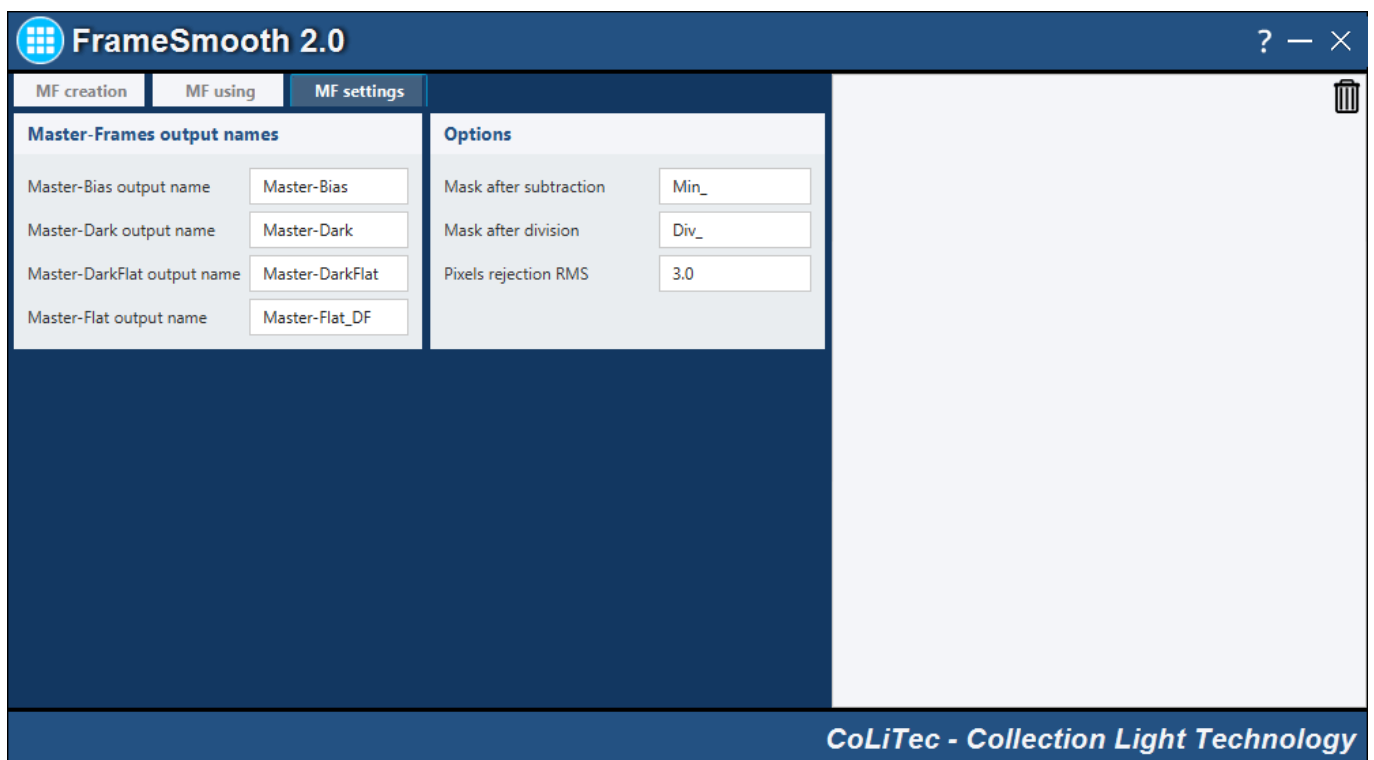
11.3. Master-Frames settings

Fig. 7

Parameters description:

1. **"*Master-Frames output names*"** pane allows you to specify the names of the master-frames for "***MF creation***" mode.

2. **"Options"** pane:

   "*Mask after subtraction*" – a prefix to the name of the target (Light) frames after subtraction operation;

   "*Mask after division*" – a prefix to the name of the target (Light) frames after division operation;

   "*Pixels rejection RMS*" – coefficient of the pixels rejection in an operation of master-frames creation.

12. OLDAS (on-line data analysis system) mode

Functionality section is designed for automatic on-line processing of any number of frames that can be formed by different telescopes.
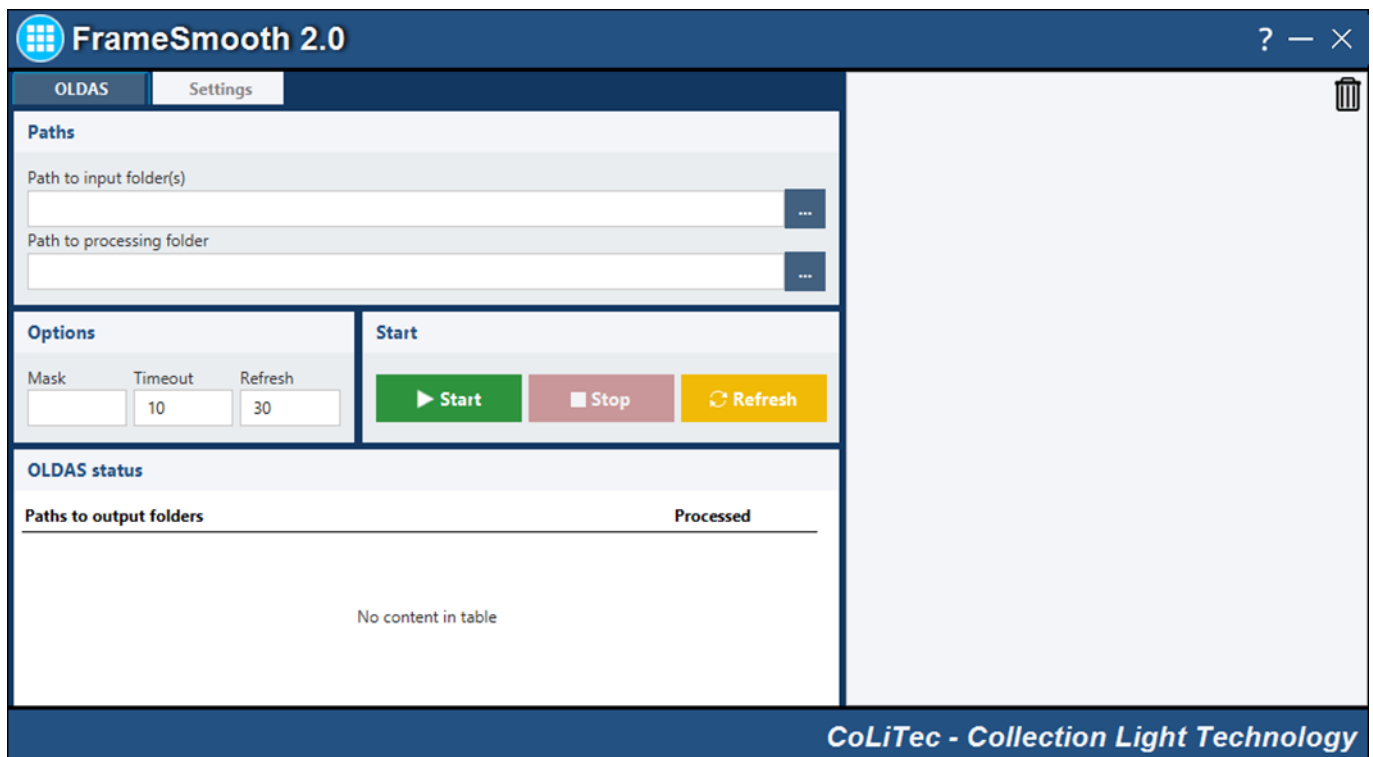

Fig. 8

OLDAS mode performs the following functions:

1. On-line search for frames in the specified input directory;
2. Copy the frames found in the directory for processing;
3. Search for the appropriate master-frames (bias, dark, darkflat, flat), if not set by the user;
4. Master-frames creation and using;
5. Inverse median filter using.

To start OLDAS perform the following steps:

1. Set the number of cores (main window, configuration) that will be available for the program (we recommend to leave at least one core for the needs of other processes). This parameter determines the number of running CLTClone programs that will be look for the task (frame alignment).

2. It is necessary to specify the "*Path to input folder(s)*" with frames that are already located in it or will be created (i.e. by telescope during observation). The structure of output folders will be the same as the structure of the input folders.

3. It is necessary to specify the "*Path to processing folder*", where frames processing (alignment) will be performed. Processing folder should be different with the input folder.

4. "Mask" parameter – mask of the frame's name that will be selected from "*input folder(s)*". By default the mask is empty that means looking for all frames.

5. "Timeout" parameter – idle time of the program, in hours. After this time all running CLTClone programs will be terminated.

6. "Refresh" parameter – frequency of updating the processing information in "*OLDAS status*" window.

7. Set required parameters in "*Settings*" tab (see section 14).

8. "Start/Stop" buttons – start/stop OLDAS processing.

9. "Refresh button" – update the information about number of processed frames.

Note 1 - location of the processed frames.

For example, two user-selected input folders (\IN_1\ and \IN_2\) and processing folder is set as (\OUT\). The processed frames will be saved in the processing folder with the same structure of folders. Moreover, additional folders «\Object» and «\Filter» will be created according to the same fields of frames header. Example in Table 1.

Table 1

Catalog search frames	Frames location	Directory for processing	Aligned frames
\TestFS\IN_1	**\TestFS\IN_1**KIC 2835289\	\TestFS\OUT\	\TestFS\OUT**IN_1\Object\Filter**KIC 2835289.fit \
\TestFS\IN_2	**\TestFS\IN_2**RXJ1803\	\TestFS\OUT\	\TestFS\OUT**IN_2\Object\Filter**RXJ1803.fit\

Note 2 - individual processing parameters for each telescope.

If you want to set "own" parameters for each telescope, such as window size for inverse median filter, using/not using some types of master-frames, do the following: save configuration file (see section 8.11) with the name, which includes the number (name) of telescope, the same as in the fit-frame header. For example, "MYSCOPE.xml". Such individual settings should be saved for EACH telescope.

Note 3 - processing folder from "Path to processing folder" should not be the same with any input folders from "Path to input folder(s)".

Note 4 - input folders from "Path to input folder(s)" should not be inside of the processing folder from "Path to processing folder". In this case, the frames will not be processed because the program excludes from processing the frames that present in the processing folder from "Path to processing folder".

13. SCRIPT mode

SCRIPT mode is designed for brightness equalization with specified sequence of operations.

SCRIPT mode allows performing the following:

1. Specify list of frames for brightness equalization "*Path to input file(s)*";
2. Search for the appropriate master-frames (bias, dark, darkflat, flat), if not set by the user;
3. Master-frames creation and using;
4. Inverse median filter using;
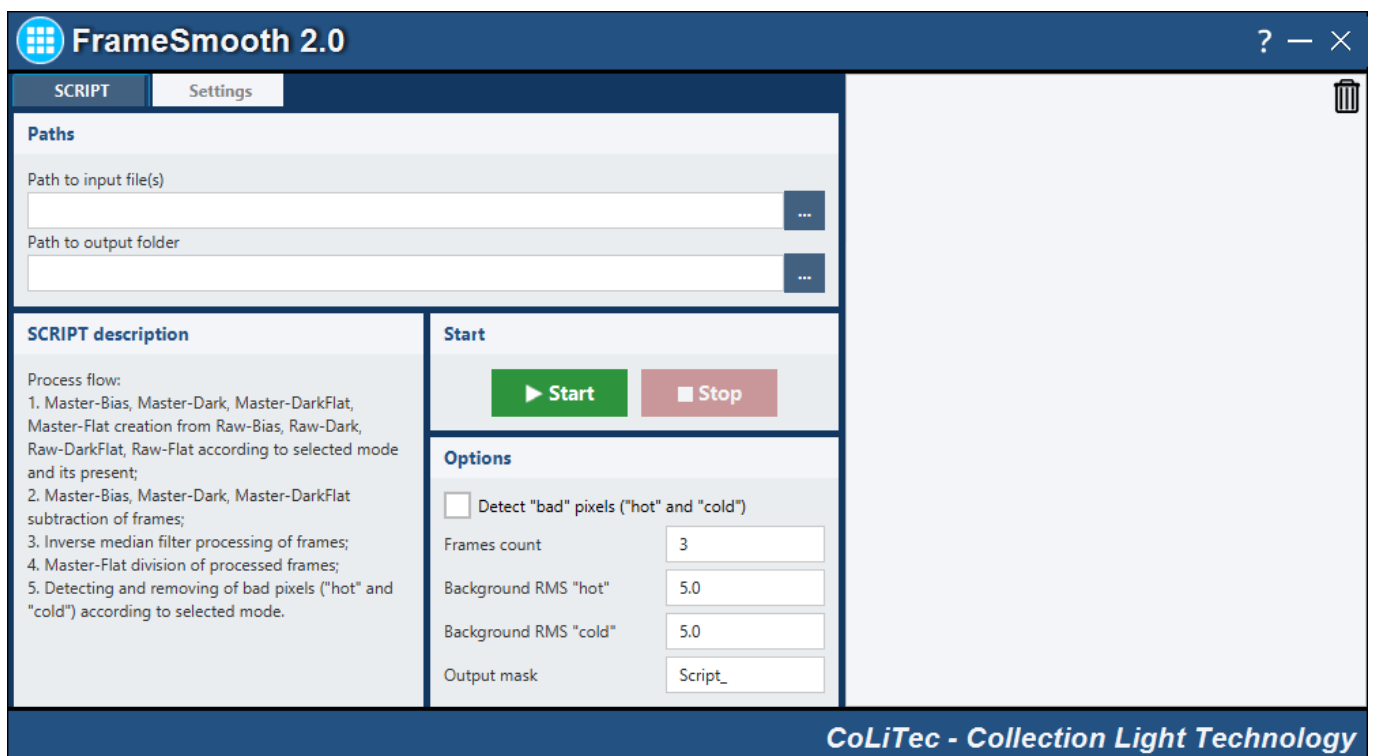5. Detection and blanking of the bad pixels.

Fig. 9

To run SCRIPT perform the following steps:

1. Select frames for brightness equalization "*Path to input file(s)*".
2. Specify processing folder "*Path to output folder*" – the folder for processed frames (if specified).
3. Set required parameters in "*Settings*" tab (see section 14).
4. Set parameters for bad pixels detection:

   "*Frames count*" – the minimum number of frames on which bad pixel should be detected;

   "*Background RMS "hot"*", "*Background RMS "cold"*" – value of "hot"/"cold" bad pixels detection.
5. Set mask "*Output mask*" for the name of processed frame.
6. Run/Stop mode – "*Start/Stop*" buttons.

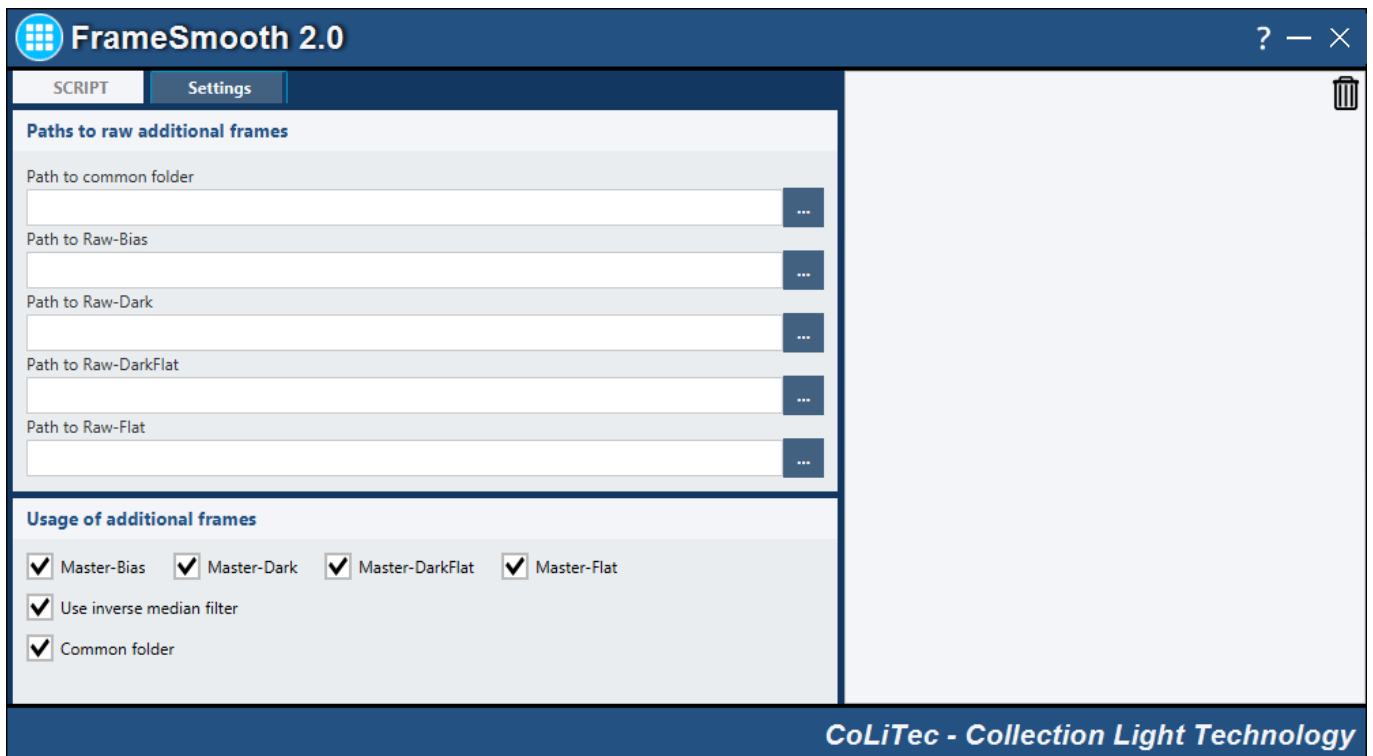## 14.   Settings for OLDAS or SCRIPT modes

Fig. 11

Parameters description:

1. Automatic search for additional frames. You should specify the directory "*Path to common folder*", and set "*Common folder*" checkbox. This directory can contain additional frames of different types and telescopes. Criteria for selection additional frames from "*Path to common folder*" directory for master-frames creation are described below:

    1.1.   For Bias – frame size, frame type ('IMAGETYP' field should contain a combination of "bias" characters), title of 'TELESCOP' telescope;

    1.2.   For Dark – frame size, temperature ('SET-TEMP'), exposure ('EXPOSURE', 'EXP-TIME', 'EXPTIME'), frame type ('IMAGETYP' field should contain a combination of "dark" characters), title of 'TELESCOP' telescope;

    1.3.   For DarkFlat – the same as for the Dark, but relative to Flat frames;

1.4. For Flat – frame size, filter type ('FILTR', 'FILTER'), frame type ('IMAGETYP' field should contain a combination of "flat" characters), title of 'TELESCOP' telescope;

1.5. Time criterion. The group of frames with the time near or early then time of the target frame will be used in processing. For example, the target frame is received on 15/10/2016, there are 20 Dark-frames from 13/10/2016 and 20 Dark-frames from 12/10/2016 in the common folder. So, 20 Dark-frames from 13/10/2016 will be taken for creation of Master-Dark frame.

2. Manual setting of the list of the additional frames. In the fields "*Path to Raw-Bias*", "*Path to Raw-Dark*", "*Path to Raw-DarkFlat*", "*Path to Raw-Flat*" specify lists of raw additional frames, from which master-frames will be created.

3. Set modes:

3.1. "*Common folder*" - use/not use the "common folder" for search of the additional frames;

3.2. "Master-Bias" – use/not use Master-Bias;

3.3. "Master-Dark" – use/not use Master-Dark;

3.4. "Master-DarkFlat" – use/not use Master-DarkFlat;

3.5. "Master-Flat" – use/not use Master-Flat;

3.6. "Use inverse median filter" – use/not use inverse median filter.