Reduction pipeline – Andrzej Baran – 05 May 2010

I. Overview

Reduction pipeline allows to make a complete reduction of frames acquired with CCD technique. It is a graphical application written in Lazarus under Linux, making use of shell codes very easy. The main window of the program consists of four tabs but number of additional smaller windows come up when necessary.
Before *finred* is started make sure that all necessary shell codes are stored in one directory (usually /home/user/bin):
fstat, fcmedian, fexpcat, ftsproc, fsubdark, fshareflt, fscflat, fflatfld, ftslgvftr, fdaophot, fallstar, daogrow, findtwo, rmef, rmsf, transfall, aptoidx, idxcorr, idxslst, lstcorr, idxecorr, daogrowtotmag, ds9
Always close second-rate windows by pressing *Done* button, if exists!
Always close ds9 to proceed to the next step! Use the newest version of ds9!

II. Getting Started

When *finred* is started you ought to select appropriate directories for binaries, calibration and photometry in *Path Menu*. In addition last item in *Path Menu* touches selection of directory for *inp* file (related to *Plot Tab*). If *inp* file is found in the selected directory then it is automatically loaded. Its usage is not required however very convenient as you will see. There is also *Status Bar* at the bottom of the main window where some reports are displayed.
When you start *finred* you can notice that fonts are not displayed correctly. To work it out, please copy *.gtkrc.mine* file to your home directory and run *finred* again. Sometimes *80* or other value inside *.gtkrc.mine* file must be adjusted to your actual preferences.

III. Calibration Tab

This *Tab* is divided into *five boxes* and one *Text field*. When you start calibration, first you ought to mark if bias or dark calibration will not be applied. In case of no bias correction all items related to bias will be disabled and the same in case of the latter option. Simultaneous *no bias* and *no dark correction* is not allowed. Note *Advanced Menu* in Menu. There is only *Extra calibration* option at the moment. It allows you to divide two median files. When you have i.e. *flat field* frames obtained in the evening and morning you can check if median frames calculated separately differs or not. Buttons in Extra calibration window have the same meaning and works as those in main *Calibration Tab.*
Please note that during calibration process all processed files are overwritten!

Although it is not necessary to proceed from *Bias box* and ending with image box I recommend to follow a standard procedure:

1/ *Bias box* (if enabled)
a/ choose pattern for your *Bias files*
b/ press *List of files* to list your chosen files
c/ by pressing *Frame statistic* you can make a statistic on all bias frames listed in *bias.cat* file

d/ *Display all* button displays all files listed in *bias.cat* by means of *ftv* (Appendix I)
e/ click *Bias Median* to calculate median bias frame
f/ *Show* buttons let you display text files inside *Text field* and *Display* buttons let you display CCD frame using *ftv*. Two *text boxes* next to *Display* button allows to set range of the displayed frame (lower->min, upper -> max).

2/ *Dark box* (if enabled)
This box contains similar stuff as the *Bias box* except *Separate exptime* and *Bias correction* buttons. The former separates dark frames with given exposure time (set in the *text box*). The latter corrects listed dark frames for median bias frame.
3/ *Flat field box*
This box contains also *Dark correction* button. If you apply *Bias correction* and use one long dark frame then it must be scaled to flat field exposure time. This step is done automatically as the exposure times are read from the headers. In case of equal exposure times the scaling factor is set to 1.
Separate filters button allows to separate flat field frames obtained in different filters. However only these kinds of description are recognized: *"U"*, *"B"*, *"V"*, *"R"*, *"I"* and *"LUMINANCE"*, *"BLUE"*, *"GREEN"*, *"RED"*, *"INFRARED"*.
choose filter listing box allows you to select one separated file and display its contents in the *text field*.

4/ *Image box*
These buttons have the same functions as already described. Last one called *Bad px correction* corrects frames for bad pixels and is mainly prepared for frames obtained with SBIG ST10XME camera. *Text box* represent sigma level. Use this button with caution!
You can also make statistics on scientific frames with *Image statistics* button. *Text box* and *Show* button has the same meaning as for the previous Tabs. Please be patient as it may take (depending on numbers of frames) a long while to proceed with all frames.

There are another two boxes right above upper left and right corners of *Text field*. The one on the left shows name of file with its contents displayed. The other one allows to upload that contents only if you made some changes in a displayed file. For some calculations an output stream is displayed in the *Text field* and stored in *output* file. *Terminate process* comes up when any process is running and allows you to stop this running process.

IV. Photometry Tab
This *Tab* allows to make a simultaneous PSF and aperture photometry of each listed frame. Photometry reduction is done by means of *Daophot* with *Allstar* and *Daogrow* package prepared by Peter B. Stetson.
First you need to choose a reference image which is using to make a list of stars necessary for further reduction. *Display* button displays image you have chosen and by pressing *OK* button your choose is confirmed (some additional processes are executed in background). *Option* button allows to set all parameters needed by *Daophot* package. If you are not familiar with this stuff you ought to acquaint

yourself with Stetson's papers. Be careful when setting *Maximum error* value. If it is too small then *daogrow* may fall into an infinity loop and the only chance to stop it is just to kill the *daogrow* code (use *kill* command in terminal). There are buttons named *U* in each but one boxes. By pressing them values from appropriate files can be uploaded. If you want to use it, please make sure that the format of files is correct. *U* button in *Daophot* box upload parameters in *Daophot Extra* box as well. Click *List of stars* button to make list of stars. When this process is executed *ftv* displays two images, one by one. First image with some stars (automatically found by *Daophot*) removed. If you think that there are other stars which should be included in analysis, circle them with region option and save region as ds9.reg file in the photometry directory. If the star is bright enough *Daophot* will take this star into account, if not sorry :(Exit the image. A second image displayed is an original reference frame. At this step you have to choose two stars which are used to calculate star's shift from the position at the reference frame. You can do this in the following way: circle two stars with region option and save region as ds9.reg in the photometry directory. Last image shows all stars with their numbers found. You can always display it loading allstars.reg file as regions for the reference image . When this process is done four button on the right with file names will be enabled. By pressing them you can see their contents. *List of files* button let you to choose scientific frames for photometry reduction. *Go* button starts the automatic reduction of all selected frames.
There are two *Text fields* with some buttons and descriptions above. One on the left displays current status during automatic reduction process. All this information is stored in run.log file which can be uploaded when some changes in *Text field* are done. One on the right displays name of a file already reduced, star's shift from reference image and 2D seeing values obtained by PSF fitting. To get correct value of seeing you have to set a proper scale factor (*Text box* above the *Text field*). When the photometry reduction is done, the contents of this *Text field* is automatically saved to *seeing.dat* file. *Terminate process* comes up when any process is running and allows you to stop this running process. If you use this button, please be patient – sometimes it works with a short delay.
Photometry Tab creates few directories where all output files are stored:
res/phot keeps files with photometry (*tot* – daogrow photometry, *idx* – PSF fitting, *nap* – aperture photometry)
res/phot/gc keeps files with modeled, observed and adopted growth curve averaged over an image (*cur* – growth curve)
res/psf keeps files with table of PSF corrections
res/subimg keeps residual frames with all analyzed stars subtracted

Name of files which has not been reduced or found are stored in *list.cat.next*. If you wish to proceed with these files only, before pressing *Go* button, just rename in shell the file to *list.cat*.

V. Plots Tab
With this Tab you can calculate differential magnitude and HJD, the most desirable values when making plots. If *Directory for plots* in *Main Menu* was selected then *input* file was loaded and you do not have to put all relevant information manually. I recommend to check if all information was loaded correctly. This Tab working on

output files created by *Daophot* package and calibrated CCD frames (photometry information is extracted from *Daophot output files* whereas time details are extracted from headers of calibrated files). Path to *Daophot output file* and calibrated CCD frames are defined by *Photometry directory* and reference image file in *PhotometryTab*. Note that extension of this file is assumed to be correct for all other files.

Please proceed from top to bottom, clicking successive buttons:

1/ *Filters*, press appropriate filter buttons and set pattern for file listing.

2/ *Star coordinates*, checked *S* button means negative declination. If a reference image in *Photometry Tab* is selected then coordinates for time of observations are calculated. This includes a correction for precession only.

3/ *Observatory info*, checked *W* button means negative longitude, checked *S* button means southern latitude. Set both coordinates with decimal format.

4/ *Time details*, *Part of HJD ...* means integer part of HJD which is subtracted to prevent huge numbers, *Time correction* allows to shift your header time by constant value to get correct time (set different than zero only if your header time is not correct).

5/ *Stars* button opens new window to assign *V* as variable star, only one at the first position and at most eight *C* as comparison stars. *UpDown* button allows to select number of stars then *Text boxes* should contain numbers of stars (the same as in *star.all-stars* file accessible from *Photometry Tab*). The buttons below mark each star as a *V* or *C* star. Question mark means there was some confusion in star numbers. Few *C* stars chosen (with numbers and marked as *C*) means that you want to create a mean comparison star before doing a differential magnitude.

6/ *tot* button checked means you want to work on files from aperture photometry while *idx* button pressed – on files from PSF fitting.

7/ *Growth curve* button extracts the observed growth curve calculated from *nap* files. Similar to *cur* files but *gc* files keep observed growth curve calculated for selected stars and all frames. The output files stored in *res/phot/gc* are named: *NumberOfStarFilterFrameName.gc*

8/ *Extract* button extracts data according to your configuration done before

Name of the output file stored in *res/phot*:
NumberOfStar.filter_tot[OR]idx[OR]nap.dat
Format of the output file: *x_coord y_coord magn err sky filename*
For nap files the format is similar however there are 12 magnitudo with their errors.

9/ *Compare* button calculates a differential magnitude

Name of the output file stored in *res/phot*:
filter+NumberOfStars_tot[OR]idx[OR]nap.cmp
Format of the output file: *magn err sky filename*

10/ *HJD* button calculates HJD for each measurement

Name of the output file stored in *res/phot*:
filter+NumberOfStars_tot[OR]idx[OR]nap.dat
Format of the output file: *HJD magn err zenith_dist Air_mass filename*

Options below are related to plotting only. In *Plot preferences field* you can select which sort of plot do you prefer. It has an effect on next *listing box (choose file)*: only

files related to your *Plot preferences field* are listed. By choosing file in *listing box* a final goal (bluish field on the right) is achieved (hopefully!).
All files created during your reduction process are stored in the selected directories so you do not have to save your work at any step.

VI. Fourier analysis – WILL BE IMPLEMENTED SOON

Calibration codes and some changes in *Daophot package* were made by Grzegorz Kopacki and Andrzej Pigulski (respectively).