TCP DATA REDUCTION TOOLS

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Three tools for data reduction are presented and explained. Two of them complement the analysis for data acquired with the TCP (Qtcp15 data acquisition program) and already pre-reduced using rtp program. They are rtft, which include several options for calculating the FT, and rtcorr for extinction correction. The last tool presented is rtcnv to convert the 1D fits images that TCP produces in 2D fits images, basically to be able to use other reduction programs.

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1. THE RTFT GUIDE

rtft is the *Real Time Fourier Transform* program that provides fast amplitude spectra of light curves obtained with rtp. The program is currently non-interactive. One input file is given and a few options are available. The output retains the format of the rtp output files, with frequency in the first column, given in micro Hertz, and data columns with amplitudes in micro modulation amplitudes (mma).

RTFP Startup

- In an xterm window, change directory to the data processing directory for the run in question.

- Locate a file for Fourier processing. This can be any light curve output from the rtp or rtcorr programs. The ".raw" file is usually not very useful for processing, but the ".dat" file can give sensible spectra when the conditions are photometric. The ".dif" file gives useful spectra when the conditions are non-photometric.

- The rtft program requires the output range of frequencies to be specified on the command line, together with the input light curve data file.

  >rtft 0 20000 phot.dif

- Useful options include -P to produce a power spectrum, -p to additionally write lists of detected peaks (for each data column), and -N to suppress normalization of the input data.

- The program produces a file with the ".sft" extension, and terminates. To see the result, start gnuplot, and give a command like:

  >plot 'phot.sft' with lines

  to see the resulting FT. The data column is easily selected in gnuplot by specifying the column in the data file to use for the x:y axes, for instance to plot the third data column

  >plot 'phot.sft' using 1:4 with lines

Data files

The rtft program normally produces only one output file with extension ".sft", containing the FT for all input columns. However, with the -p option specified, peak files are generated; one for each data column. These will have extensions ".pk0", ".pk1", ".pk2" etc.

Normalisation

rtft applies an automatic normalisation of the data (unless the -N option is given). This implies fitting a least squares line through the data points (for each data column) and subtracting, so that the input data are always variations around zero.

Fourier algorithm

The algorithm used is a "slow" Fourier transform procedure adopted from the qsft program.

2. THE RTCORR GUIDE

rtcorr is a program for doing extinction correction on Real Time photometry data. The program is completely non-interactive. One input file is given and a few options can be invoked. The output retains the format of the rtp output files, adding a few header lines with information on the processing steps applied. The rtcorr program requires two additional files with information to start the extinction correction; one file named TELESCOPE that gives information about the observatory and instrument used (and which will be the same for all targets of a given run), and one file named TARGET which gives specifics for the current TARGET. See below for details on how to create these files.

IMPORTANT: The TELESCOPE and TARGET files should be like the ones presented below. Qtcp9 creates slighty different files which <u>DO NOT</u> work.

You can find the TELESCOPE and TARGET template files are in the directory: */home/observer/HELP_files/*

RTCORR execution

- In an xterm window, change directory to the data processing directory for the run in question.

- Locate a file for extinction processing. This can be any either the ".raw" file or the ".dat" output file from rtp.

- If the ".raw" file is given, the sky level is recomputed. In this case it is possible to give the option -b [num], which will smooth the sky values with a boxcar function of width [num] data points, before sky subtraction. As with rtp the option -t [num] can be used to specify a sky field different from the first.

- Normally the rtcorr program is executed simply like this;

  > rtcorr phot.dat

  provided that the TELESCOPE and TARGET files have been properly set up.

- A -w [num] option can be given to get tapering of the light curve, where num is the number of data points to taper on each end of the data set. This produces an additional output file with the data tapering towards zero at the ends. This is normally not recommended.

The TELESCOPE file

The TELESCOPE file should look something like this:

Observatory: "Nordic Optical Telescope"
Longitude: "-17d53m06.3s" # Negative for West / Positive for East
Latitude: "+28d45m26.2s"
Altitude: "2465.5m"
Instrument: "ALFOSC"
Filters: "XUBVRIWrX" # Filter in position 012345678

The longitude and latitude values are used for the extinction correction. The observatory and instrument names used only read by rtp to put in the data file headers, overriding the FITS keywords. The filters sequence is important. It tells rtcorr what filter correspond to which extinction coefficient in the TARGET file. rtpextracts the filter number from the FITS header and puts this in the output files. rtcorr then selects the filter letter based on the position of the letters in the Filters string. For standard filters the order is rarely changed.

The TARGET file

The TARGET file should look something like this:

Target information:
TARGET: "PG 1336-013"
RA(B1950): "13h36m13.3s"
DEC(B1950): "-01d46m34s"
Observation run information:
DATE: "2001-05-04"
TIME(UT):   "22:30:45"
Extinction coefficients for the IAC80
K_U: "0.50"
K_B: "0.33"
K_V: "0.22"
K_R: "0.14"
K_I: "0.08"
K_W: "0.15"

The target name is only passed on to the output files for information purposes, together with the coordinates and date/time of start. The target coordinates and start time is of course used for calculating the airmass. **The extinction coefficients given here are typical for the Teide Observatory,** but may change significantly depending on the conditions.

Note that the almanac is not updated so, for now, it is necessary to introduce the DATE using the year 2002 or less. However, changes due to this are not important

Copy the TELESCOPE and TARGET files

The easiest way to get started with rtcorr is simply to copy the TELESCOPE and TARGET files from the ~fastphot directory.

Output files

rtcorr normally produces three output files.

- A ".ext" file, containing the extinction corrected photometry.

- A ".edm" file, containing the extinction corrected differential photometry.

- A ".nma" file, containing the ".edm" data normalised in the same way as rtft will do. There is no difference between passing the .edm file or the .nma file to rtft. The .nma file is provided only to show what the light curve will look like after normalisation.

- A ".ras" file will be generated when giving a .raw file as input, and it will contain the new sky subtracted data (with optional box average processing) for comparison with the standard .dat file.

- A ".win" file can also be generated, if the -w option is applied, containing the .nma data with tapered ends.

3. THE RTCNV GUIDE

(Short recipe in spanish in second page)

rtcnv is a program to convert the fast photometry CCD window data files into 2D images that can be displayed with saoimage or processed with other image processing software. The program can operate in several ways, depending on the purpose. In the simplest mode, it reads the input "w00000.fits" (etc) files, and converts them to 2D output files; "view00000.fits" (etc). In the most advanced modes, the exact same processing steps as in rtp are made, except that the processed frames with imposed aperture masks are written as fits files, instead of summed.

Creating visualisations

If you want to visualise what is going on in the apertures as rtp process the images, it is possible with *rtcnv* to create image strips with target channels vertically and sequence frame numbers in the horizontal direction. The following options are relevant;

- Use -n [num] to specify the number of sequence frames to convert.
- Use -o [num] to specify the offset between consecutive frames.
- Use -s [num] to specify the start frame.
- Use -w [num] to specify the number of target windows to include.
- Apart from that, use the same options as with rtp.

For example;

>rtcnv -n 20 -o 10 -s 200 -MO -i 5 -r 18 -z 2

produces an image strip with 20 frames processing data file "w00200.fits", "w00210.fits", "w00220.fits", ... up to "w00390.fits", showing the target stars in centered apertures and with two sky fields on the top. The output filename will always be "view.fits".

Creating files for later processing

If data files that can be processed with other software are required, start rtcnv with the -I option. This produces one file for each image processed, with consecutive numbering; "view00000.fits", "view00001.fits", etc. In this case it is useful to suppress much of the processing of the images. The following options are useful;

- Use -X to suppress the aperture masks.

- Use -S to suppress the sky level subtraction.

- Use -B to suppress the bias level removal.

- Use -R to get the raw sequence. That is, the images sorted as they are read from the CCD, and not sorted to the original window list.

APPENDIX: Short recipe for rtcnv

To transform all the images to unprocessed 2D fits (only bias substracted), use:

  - Create a new directory (at the level of *data, tcp*...).

  >mkdir images

  >cd images

  - We recommend copy to this directory the super-flat (Flat.fits) created by *rtp*. If the super-flat is here, the resultant images will be flat-fielded.

  >ln -s ../data .

  >rtcnv -X -S -I -n xxx (where xxx is the number of images –by default, it stars in w00000.fits-).

More info in:

  http://www.not.iac.es/instruments/alfosc/fastphot/index.html

CAUTION: the final files will be named "viewxxxxx.fits" and they will not have headers!