New Capabilities of the Software to Support Digitization of Astronomical Photographic Plates

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Abstract. In this article, we announce improvements to two applications for digitizing astronomical photographic plates and developing a new one. In the software for creating the header of fits file using the data from WFPDB (wfpdb.org) we add feature for processing data for multiexposure plates. A new functionality of application for updating fits header allow us to complete fits header for fits files obtained from ImageMagic application. The development of virtual observatories has prompted us to realize a convertor of fits header to GAVO (www.g-vo.org) standard.

1 Wide-Field Plate Database

There are about 2 475 000 astronomical photographic plates all over the world. Wide-Field Plate Database (`www.wfpdb.org`) is WEB-based database that contains meta-data for more than 600 thousand plates [1]. It is one wide-field unique telescope, giving access to unique photographic astronomical observations, done systematically in the period 1880 – 2000!

The Catalogue of Wide-Field Plate Indexes contains meta-data for plates. For every plate many details are stored in the database: the coordinates of the plate center, the date and time of the observation, object name and type, method of observation, duration of exposures, type of emulsion, the size of the plate, the quality of the plate, the name of the observer, etc.

The meta-data of the plates are distributed in 6 plain-text files. For every file we give an example – one line in a file contains the data for a plate with identifier `ESO040 007863`.

- The most important information is in the `maindata` file:
  ```
  ESO040 007863 053517-052328 19850114012100 ORION M42-43 NGC1976  S42 6120.0KODAK
   IIaO        Pg161611111
  ```

- Availability file:
  ```
  ESO040 007863  PLATE IS AVIALABLE AT THE WFPDB DEPOSITORY, SOFIA,  BULGARIA:
   milcho.tsvetkov@gmail.com
  ```

- Notes file:
  ```
  ESO040 007863 ORIG_COORD:053400-052400 ST.ST=     ST.END=0620 UT.ST=0121
   UT.END=0329   MULTIP. EXPOS=6X20  FL! ANON     L
   EXP1-6_UT_STARTUT_END=01:21-01:41,01:42-02:02,02:03-02:23,02:27-02:47,
   02:48-03:08,03:09-03:29;
  ```

- Observer file:
  ```
  ESO040 007863  W.SEITTER
  ```

- Quality file:
  ```
  ESO040 007863  3   ARCSEC SEEINGS
  ```

- Digitization file:
  ```
  ESO040 007863 DIGITISED WITH PDS2020 AT AIM, AND IN THE WFPDB WITH THE
   FB SCANNER EPSON PERFECTION V700 20MIC PIXEL(1200DPI)
  ```

2   Plate digitization

Plate image is a digitized astronomical photographic plate image ((16-bit grayscale FITS file), with high resolution aiming photometric and astrometric measurements.

The process of plate digitization cosists of 3 steps:

- Scanning the plate (image) to produce `.tif` (row-tiff) file [4].

    – Hardware: flatbed scanner *and*

    – Software: VueScan

- Completing metadata (header) to produce `.hdr` file

    – Transfering data from WFPDB: `header` application *and*

    – Adding actual data for scanning, time, etc.: `header` application

- Completing header file and merging it with image file to produce `.fits` file

    – `Tif2fits` application *or*

    – ImageMagic software + `UpdateFitsHdr` application

3   Header

The FITS header contains the complete metadata for the plate, the telescope, the place of the observation, the scanning process, etc. The main part of these data can be extracted from the corresponding WFPDB catalogues. This approach presumes that the collection of plates for digitization (plate archive) is already described in WFPDB. The second part of the data consists of constant values, and the third part can be calculated using the other parts.

`.hdr` denotes a plain text file producing by `FITS header` application.

- Most of the data for fits header can be extracted from WFPDB.

- Additional data can be entered manually or automaticaly.

Figure 1 presents the general view of `FITS header` application.

The format of the data in the FITS header is stricly defined (see [5] and [6]) but the extended content is very flexible. There are some specific data for photographic plates, comparing with CCD images. Our choice of key words, fieldas and mesurement units is defined from practice with various plate archives [3]. The development of virtual observatories (VO) during last years has prompted us to adapt out software for FITS headers for facilitatation the publication of digitized archives in VO.

The important place for our digitized archives is German Astrophysical Virtual Observatory (GAVO) and our goal is to satisfy the requirements of GAVO.

GAVO header sections are:

- ”Basic data”

- Original data of observation

- Observatory and instrument

- Photographic plate

- Derived observation data

- Scan details

- Data files
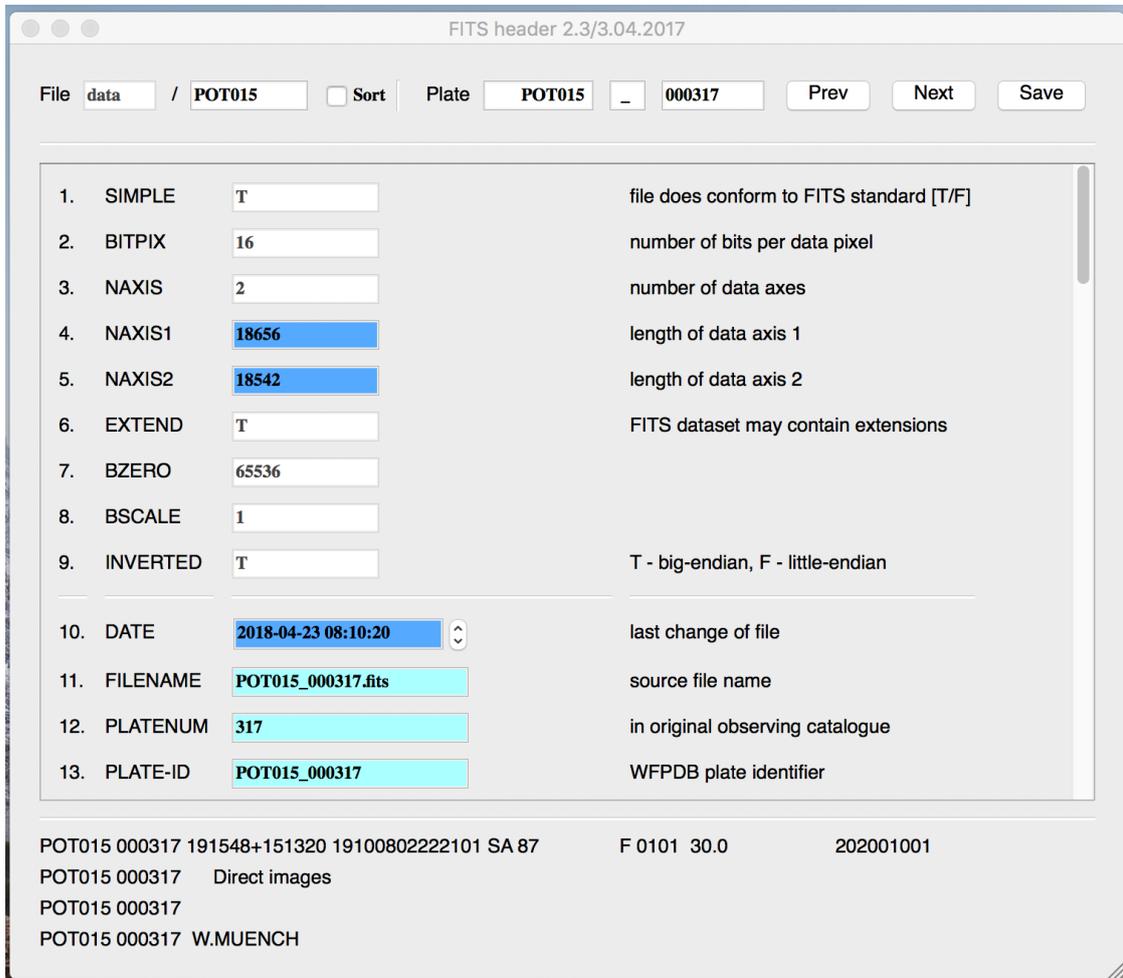
Figure 1: A part of the user interface of `FITS header` application.

The data from WFPDB is transfered to `.hdr` file but the complete FITS header comtains also information for image and we denote this file as `.hdrf` file (for easy on-line access to the plate metadata.). If we denote by `.hdrg` GAVO header, we need the following convertors for various "standarts":

- WFPDB → .hdr

- .hdr → .hdrg

- .hdrf → .hdrg

Example of differences betweeen two formats:
.hdrf: `UT      = '1911-02-02 01:31:39' / date and UT at mean epoch`
.hdrg: `DATE-AVG= '1911-02-02T01:31:39Z' / UT d/t mid-point of observation`

4   Processing image

While VueScan produces `.tif` image forrmat files, the conversion to `.fits` image format (including header) can be done in two ways – using `Tif2fits` application or using a combination of ImageMagic software and our `UpdateFitsHdr` application. `Tif2fits` transforms `.tif` and `.hdr` files to `.fits` and `.hdrf` files (Figure 2).

ImageMagic converts `.tif` to `.fits` file with very small FITS header. `UpdateFitsHdr` application repaces this small header using `.hdr` file and produces normal `.fits` file and `.hdrf` header file (Figure 3).
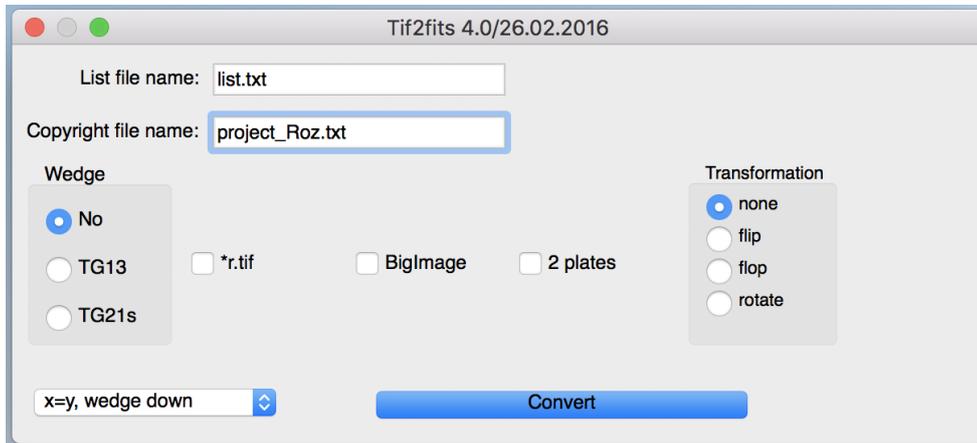
Figure 2: User interface of `Tif2fits` application.
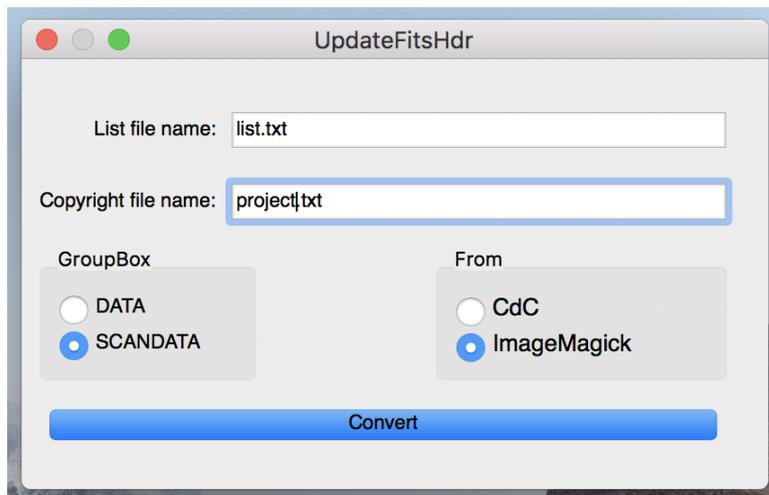
Figure 3: User interface of `UpdateFitsHdr` application.

5 Multiple exposure

Multi exposure plates contain several exposures and its header has to contain data for every single exposure. This way the header turns to variable number of fields (lines), which does not match to `FITS header` application. `MultiExp` application solves the problem extendeing `.hdr` or `.hdrf` file (Figure 4).

The data for every exposure can be found in WFPDB – Notes file.

Example of a part of a line for one plate in WFPDB and the same data in FITS header for that plate.

```
WFPDB Notes file:
UT_STARTUT_END=01:21-01:41,01:42-02:02,02:03-02:23,02:27-02:47,02:48-03:08,03:09-03:29;

.hdrg file:
DT-OBS1 = '1985-01-10T01:21:00Z'
DT-AVG1 = '1985-01-10T01:31:00Z'
DT-END1 = '1985-01-10T01:41:00Z'
EXPTIM1 =                 1200.0
DT-OBS2 = '1985-01-10T01:42:00Z'
...
```

6 Conclusion

The software is written in C++ using Qt – cross-platform application and UI development framework (`www.qt.io`). The applications are publicly available in GitHub as open source (`github.com/nkirov`).
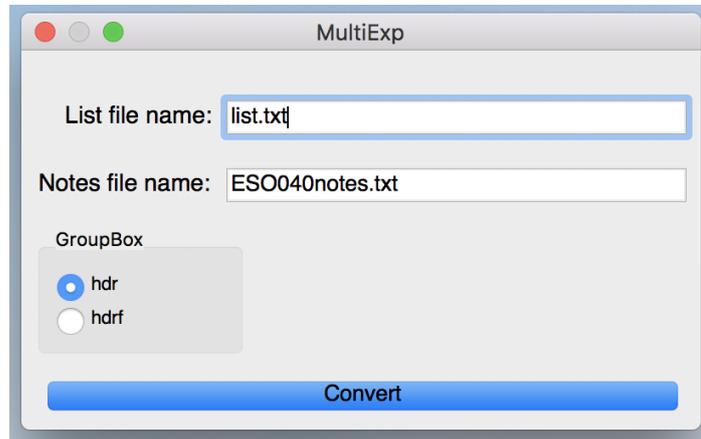
Figure 4: User interface of `MultiExp` application.

References

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[5] FITS header format: 2014 https://www.plate-archive.org/wiki/index.php/FITS_header_format

[6] FITS Standard Document: 2016 https://fits.gsfc.nasa.gov/fits_standard.html