Automatic Réseau Grid Lines Removal from Carte du Ciel Plates

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Introduction

The réseau grid of 27 horizontal and 27 vertical lines was originally superimposed over Carte du Ciel (CdC) plates to assist the process of visual measurements of stellar images. Yet, it significantly complicates the automatic extraction of astrometrically precise data. Stars detection is hampered by the blending of star image intensities with those from the grid (partial or entire star occlusion by the grid) and false detections along the grid lines.

We propose an automatic réseau grid removal approach over arbitrary plates with no prior knowledge on the plate's position over the sky. The uniform spread of vertical and horizontal grid lines is addressed by using projection profiles along both image axes to locate the local maxima, corresponding to the skeleton of each grid line.

Materials and methods

The experimental study was carried out over CdC plates from the Astronomical Observatory Potsdam. Additional information for the Potsdam Carte du Ciel plates can be found in Tsvetkova et al. (2009).

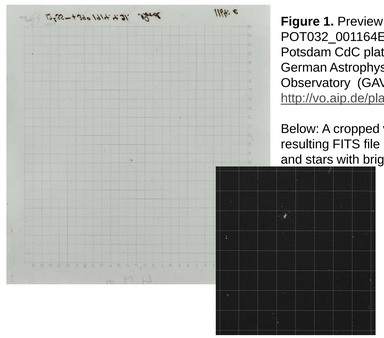


Figure 1. Preview of plate POT032_001164E as one of the Potsdam CdC plates included in the German Astrophysical Virtual Observatory (GAVO) - to be found at http://vo.aip.de/plates/picindex.html.

Below: A cropped version of the resulting FITS file displays the grid lines and stars with bright intensity.

In the course of the experimental research a few scenarios have been investigated:

- **Morphological erosion** with horizontal and vertical line as a structural element. Good results, inefficient over enormous images.

- **Fourier Transform** . Same maxima detection problem but in the frequency domain. High performance cost.

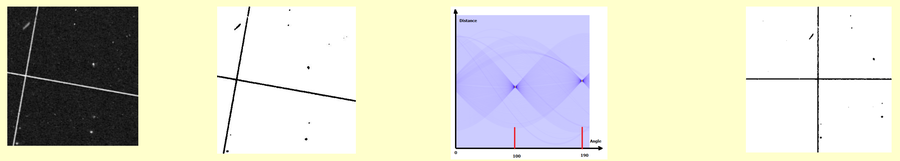
- **Non linear filtering** to suppress the grid lines – use the EyE tool (Bertin & Marmo, 2006) of the Astromatic software suite. The filter applies over the entire image and spoils all bright intensities.

- **Maxima location over projection profiles**. Good performance. A similar approach was suggested by Vicente et al. (2007), using marginal distribution along both axes.

Approach

1.Geometrical Orientation

Hough Transform over a small central area (500 x 500px) gives the slants of the grid lines. The original plate image is rotated in accordance with this slant so the grid's horizontal/vertical lines be parallel to the horizontal/vertical coordinate axes.



Cropped central region, artificially rotated at 10° → Binarization → Hough Transform: detects lines at 10° (vertical) and 100° (horizontal) → Oriented image: rotation at -10°

2.Projection Profiles

The vertical and horizontal projection profiles help locate the respective intensity heavy lines – image columns or rows – that appear as local maxima.

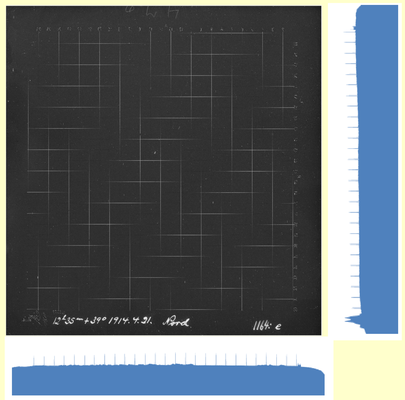


Figure 2. The original image with its

horizontal $A(y)=\sum_{i=1}^{M} I(y,i),\ y=1,\ldots,N$

and vertical $B(x)=\sum_{i=1}^{N} I(x,i),\ x=1,\ldots,M$

projection profiles.

Fairly uniform spikes indicate the position of the intensity heavy grid line candidates. Total number of lines = 14'644.

3.Thresholding

Apply two consecutive thresholding passes over each of the projection profiles. In the **first pass** we use a moving window and eliminate the lines below the window's average brightness – this reduces the influence of regions of high intensity (i.e. star clouds, nebula, galaxies, plate artifacts). In the **second pass** we repeat the above step but consider only one window, containing all remaining lines .

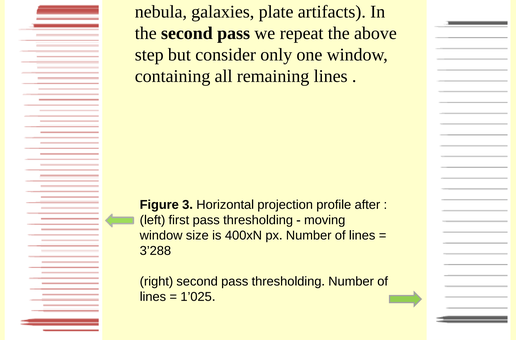


Figure 3. Horizontal projection profile after : (left) first pass thresholding - moving window size is 400xN px. Number of lines = 3'288

(right) second pass thresholding. Number of lines = 1'025.

4. Grid uniformity detection

For each projection profile consider those local maxima that are in a uniform distance of [450-500] pixels from each other. Their number should be 27. These maxima correspond to the skeletons of the grid lines. The actual grid lines are represented with decreasing intensity over 3-4 pixels on both sides of the skeleton.

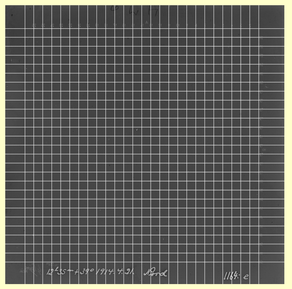


Figure 4. Preview of plate POT032_001164E with the detected grid superimposed

5. Grid replotting and usage

The located grid can be suppressed or removed by plotting it over the original image with a very low intensity.

The detected grid coordinates can be used to generate a "flag-map" and provide it as a parameter to Sextractor (Bertin & Arnouts 1996) - the star detection software tool. This will mask out the grid pixels as e.g. bad regions and will set a special flag (in Sextractor's output catalog) to the detected objects, that fall over the grid.

Literature cited

K. Tsvetkova, M. Tsvetkov, P. Böhm, M. Steinmetz, andW.R. Dick, "The Potsdam plates of the Carte du Ciel project: I. Present inventory and plate catalogue," Astron. Nachr., 330(8): 878–884 , 2009.

B. Vicente, C. Abad, and F. Garzón, "Astrometry with Carte du Ciel plates, San Fernando zone. I. Digitization and measurement using a flatbed scanner," Astronomy and Astrophysics, 471(3): 1077-1089, 2007.

E. Bertin, S. Arnouts, "SExtractor: Software for source extraction," Astronomy and Astrophysics Supplement Series, 117: 393-404, 1996

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For further information

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More information on this and related projects can be obtained at http://www.astroinformatics.eu

Conclusions

The proposed approach for the automatic grid lines detection has a fair processing time of ~ 55 sec. per plate of 14'644x14'644px (load, save, and rotation times ignored) on a Intel i7, 2.67 GHz CPU.

Optimizations are envisioned to substitute entire image rotation by including the rotation angle in the calculation of the image lines.

Future steps include the detection and suppression of grid numbers and handwritten texts around the plate borders.