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# Image processing of historical astronomical plates

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**Abstract.** Many fields of X–ray astrophysics require multifrequency data including optical. Long-term data, such as provided by data archives, have special value. Historical astronomical plates were main source of data for more than century, not only for photometry, but also for spectroscopy. There are still millions of plates worldwide which have never been processed by modern computers. There are some standard ways how to process images applicable on astronomic plates. But also many specific methods that must be developed for processing of plates.

**Key words:** Historical – Plates – Astrometry

## 1. Introduction

Historical continuity of observation is the main value of the astronomical plates nowadays. For more than century emulsion on glass plates served as main tool for image acquisition. Due to poor sensitivity, long exposures and large aperture were mandatory. Combination with wide field telescope caused distortion and other aberrations at the edges of the image. Then after evaluation, plates were stored in archives. For long term archivation certain conditions must be met. Low humidity and constant temperature as well as special folders are more or less exceptions. For these reasons many of the plates suffers from fungi, golden illness, emulsion peeling and others complications, that reduces image quality and plates durability. For this reason quick method of digitalization is needed, as the emulsion degradation can be fast.

For digitalization, Nikon D800E with high–quality lens was used. With resolution of 36 MPx it can yield high enough pixel density compared to grain of emulsion of middle sized astronomic al plates (Hudec & Hudec, 2013). For very small plates and negatives, such as spectral plates, the method provides very small pixel sizes. Plates are put on specialized lighting panel and after focusing and adjusting procedure many plates can be quickly photographed (Hudec & Hudec, 2014a). Not only glass plates but also photographic emulsions on plastics (planfims) can be digitized this way. The method is very fast and effective, one can easily digitize up to 1 000 plates in just one day, significantly more than can be achieved with another plate digitizing methods, e.g. plate scanners (which in addition have different scanning quality for each axis due to moving parts). So far, more than 30 000 astronomical plates (not only direct images but also low–dispersive spectral images and spectra) were digitized by our team with this method. For the detailed technique and hardware description see (Hudec & Hudec, 2014b).

After digitalization, phase of data restoration follows. Image processing is complicated by fact that telescope used for acquisition usually introduces some small distortion, but when the plates are digitalized by camera, then distortion of lenses is introduced too. For this reason chessboard test image is photographed as target for lens distortion removal. Also when plates doesn't fill the image, then automatic cropping is applied to save archive space. Typical digitalized image is shown in Fig. 1.

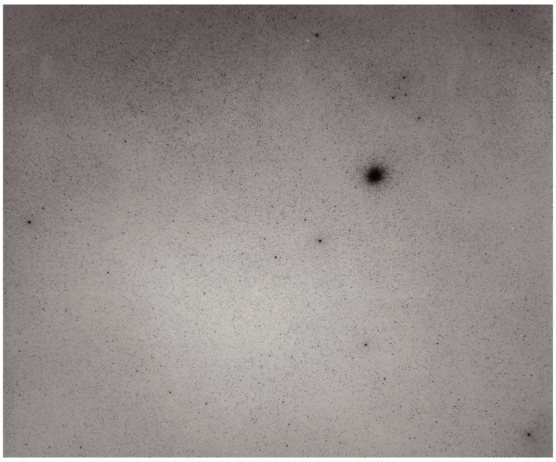

**Figure 1.** Digitalized and cropped image of M22 star cluster. Field of view is $200 \times 240$ arcminutes. Focal length is 310 mm.

## 2. Astrometric calibration

First experiments were made with astrometric calibration to verify precision of digitalization. WCS header (Calabretta & Greisen, 2002) was created using Astrometry.net (Lang et al., 2010). This service enables usage of linear coordinates but also tweak coordinates using second or higher polynomials. As Fig. 2 shows image is well fitted using even only linear calibration. However, apparent trend is visible in right ascension meantime declination axis is very precisely fitted.

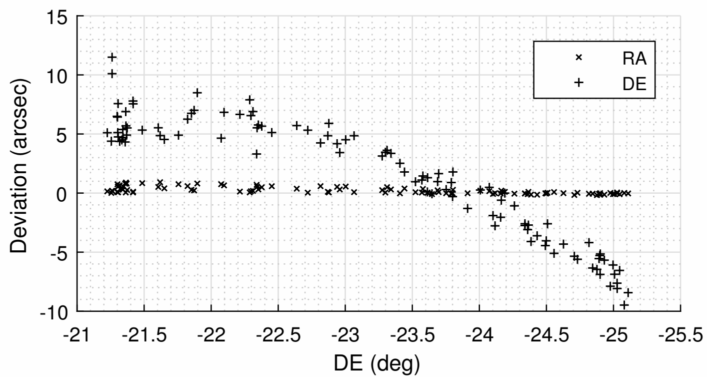


**Figure 2.** 3D plot of angular deviations from linear astrometric solution view from declination - deviation plane. Right ascension axis is oriented towards inwards.

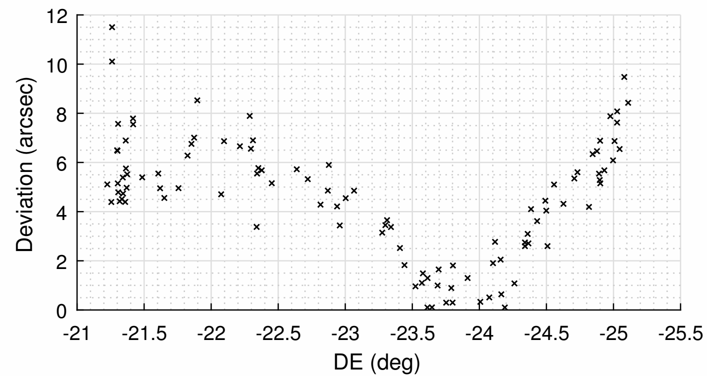


**Figure 3.** 3D plot of angular deviations from linear astrometric solution combined data RA and DE view from declination - deviation plane. Right ascension axis is oriented towards inwards.

In the Fig. 3 quadratic sum of deviations both RA and DE is shown. In Fig. 4 we show the positional residuals if a third order polynomial is used, together with the stars used to compute the astrometric solution. Evident trend is recognized again. It is clear that for really precise coordinates retrieval SIP (Simple Image Polynomial) of second or even third order should be used. But problem is with FITS WCS header standards. None of the standard programs tested fully support usage of SIP – Aladin, DS9 (Smithsonian Astrophysical Observatory, 2000; Bonnarel et al., 2000). Therefore next work will be put on tool for coordinates retrieval and evaluation.

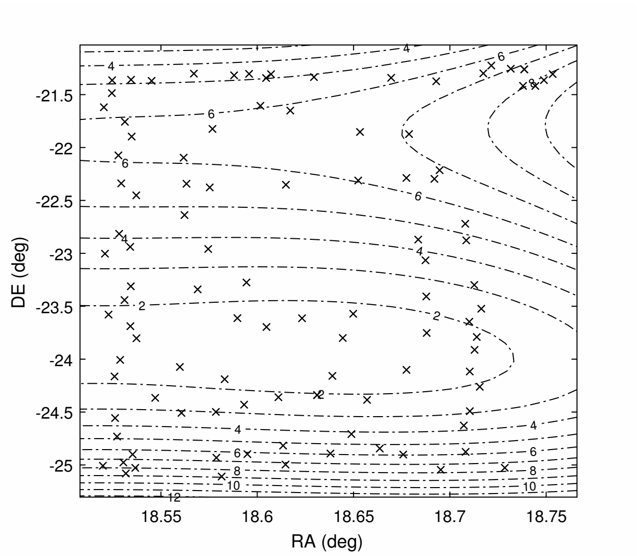


**Figure 4.** Contour plot of angular deviations in arcseconds combined from both RA and DE with measured stars marked.

## 3. Conclusion

With no really dedicated software for astronomical plates processing, we are at beginning of process to design and implement all procedures ourselves. Process of digitalization by digital camera gives good results and astrometry can be done with enough precision to identify targets in catalogs. In future we plan to implement SIP to increase precision in corners.

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