ASTROMETRY TEST OF MSCRED IRAF SOFTWARE PACKAGE

R. Popescu, P. Popescu, P. Paraschiv and A. Nedelcu

Astronomical Institute of the Romanian Academy
Str. Cutitul de Argint 5, RO-040558 Bucharest, Romania

SUMMARY: Astrometric properties of images obtained using MSCRED IRAF software package are investigated. CCD observations of M35 open cluster were taken in an observation run between October 10 and 17, 2004 at Belogradchick Observatory (Bulgaria) using the 60cm Cassegrain telescope endowed with a 1kX1k Apogee 47P CCD camera, ensuring to a field size of 6.16 square minutes, with a scale of 0.722arcsec/pixel in 2X2 binned mode. Dithered images are resampled and reansambled into a single larger image for which the World Coordinate System (WCS) solution is recomputed and investigated.

Key words. Astrometry – Reference Systems

1. INTRODUCTION

IRAF (`http://iraf.noao.edu`) is the Image Reduction and Analysis Facility, a general purpose software system for the reduction and analysis of astronomical data. The main IRAF distribution includes a selection of programs for general image processing and graphics, and a large number of programs for the reduction and analysis of optical and IR astronomy data, available as NOAO package. The IRAF core system is the basic IRAF system and does not include the suite of reduction packages known as the NOAO package. The IRAF core system provides tools for reading and writing data in the FITS format, interactive graphics, image arithmetic, image statistics, image frames combining while NOAO package provides basic CCD reductions and flat fielding routines, spectra analysis, photometry and astrometry routines. These tasks are available in both batch and interactive modes.

Other external or layered packages are available for applications, such as data acquisition or handling data from other observatories, and wavelength regimes such as the Hubble Space Telescope (optical), EUVE (extreme ultra-violet), or ROSAT and AXAF (X-ray). The external packages are supplied separately from the main IRAF distribution, and can be installed as needed. One such external packages is MSCRED (Valdes 1998), the CCD mosaic data handling software. It includes functions for reduction of mosaic exposures and fringe pattern removal together with routines for combinig dithered or rastered exposures with respect to a common coordinate system. An image of this type is first resampled into an image in a celestial coordinate system that can be shifted by integer amounts along both image axes before combining.

2. OBSERVATIONS AND DATA PROCESSING

The observations were carried out using a 60cm F/12.5 Cassegrain telescope at Belogradchick Obervatory, Bulgaria under good sky condition. The detector was an Apogee 47P CCD camera with a MAC47-10 chip the dimension of which were 1024 X 1024 pixels, 13 microns each, and was used in 2X2 binned mode leading to a 6.16square arcmin

size Field of View (FOV) with a pixel scale of 0.722 arcsec/pixel. No filter was used. During this observations run dedicated to CCD imaging of optical counterparts of International Celestial Reference Frame (ICRF) radiosources several fields with high stars density were imaged. One of these regions was M35, the core of which was covered by 3x2 overlapping frames.

The software used for image reduction and analysis was IRAF, both for bias, dark and flat corrections, and for the astrometric computations. Positions of stellar objects in CCD images are extracted using *daofind* routine. Catalog data (USNO B1.0, UCAC2, 2MASS) for the selected area were obtained using batch mode scripts from VizieR web service, then *ccxymatch* was used to match stelar positions from the catalogs with the positions extracted from CCD images by *daofind*. Finaly, with the matched star list from *ccxymatch*, *ccmap* computed the plate solution and added WCS informations to the FITS headers for each image. Fake matching induced by bright stars near the image edge were rejected by choosing a matching tolerance of 0.5 pixels.

The catalog chosen for the reference stars was UCAC2 (Zacharias et al. 2004), an astrometric catalog containing 48,330,571 stars from declination -90 to +40. It resulted from R CCD observations, between 7.5 and 16 magnitude. The positional errors were at 20 mas in the 10th to 14th magnitude interval, and at 70 mas in the limiting magnitudes.

Having WCS headers for all the frames, one could use *mscimage* routine that produced images which were sampled on an even grid of pixels in the sky. By using the same grid for dithered or rastered sets of observations, the images could then be combined using only integer pixel shifts in the two image axes. The goal was to have only a single interpolation of the data. In the next step, *imcombine* used coordinate system produced by *mscimage* to shift and then combine dithered or rastered observations.
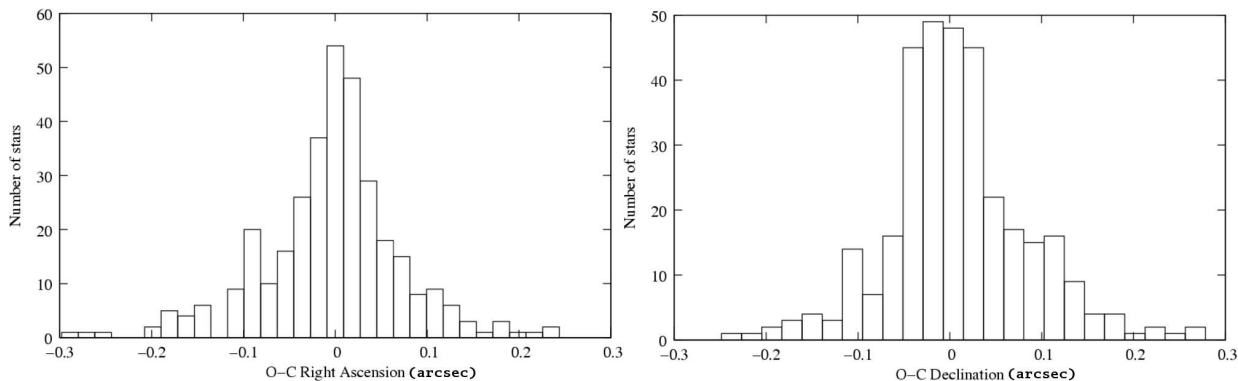

Fig. 1. *WCS residuals in right ascension and declination for reference stars from the six original frames.*
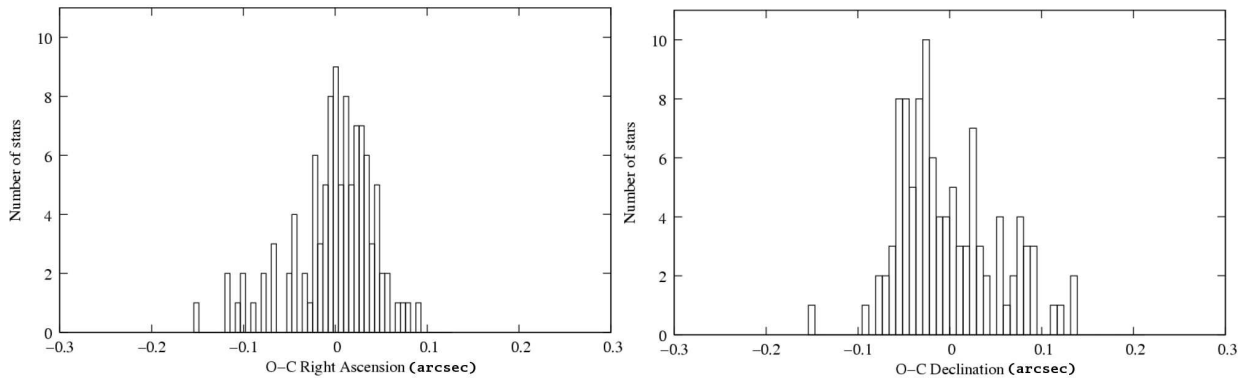

Fig. 2. *WCS residuals in right ascension and declination for reference stars from the constructed mosaic.*

Table 1. Standard deviations of WCS residuals in α and δ for the original frames and the constructed mosaic

	σ_{O-C_α} (arcsec)	σ_{O-C_δ} (arcsec)
Original Frames	0.116	0.090
MSCRED Mosaic	0.045	0.052

To investigate the mosaic image, we applied the same procedure of astrometric computation described above, in the same manner as for the original frames. Fig. 1 shows the WCS mapping status for all the original frames, and Fig. 2 gives the mosaic constructed with the numerical data given in Table 1.

3. RESULTS AND CONCLUSIONS

Table 1 shows an improvement in quality of WCS solution for the MSCRED mosaic, as compared with any of the original CCD frames. The explanation is that now, having a wider FOV, one can choose reference stars labeled as "astrometrically excellent", with direct impact on reliability of computed plate solution. The method can be applied to the deep astrometry (high-precision positions and absolute proper motions), to contribute to a comprehensive photometric, astrometric, and spectroscopic database for selected fundamental open clusters. Also, in the field of astrometry of optical counterparts of ICRF sources, the method allows a direct connection with reference stars previously determined by photo plates programs as CONFOR (Babenko et al. 2003) and, thus, to overcome some of the drawbacks of the narrow field astrometry.

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АСТРОМЕТРИЈСКИ ТЕСТ КОРИСТЕЋИ ПРОГРАМСКИ ПАКЕТ MSCRED IRAF

R. Popescu, P. Popescu, P. Paraschiv and A. Nedelcu

Astronomical Institute of the Romanian Academy
Str. Cutitul de Argint 5, RO-040558 Bucharest, Romania

У раду су испитиване астрометријске особине CCD снимака користећи програмски пакет MSCRED IRAF. Снимано је отворено јато M35 од 10. до 17. октобра 2004. године на опсерваторији Belogradchick (Бугарска) користећи 60 cm Cassegrain телескоп са Apogee 47P CCD камером 1kx1k. Поље вида је било 6.16 arcmin са скалом од 0.722 arcsec по пикселу и биновањем 2x2 пиксела. Више снимака је укључено у једну велику слику за коју је рачунат и испитиван систем WCS.