Correcting the Astrometry of DASCH scanned plates

Mathieu Servillat – Harvard College Observatory – mservillat@cfa.harvard.edu
Edward J. Los, Jonathan Grindlay, Sumin Tang (HCO), Silas Laycock (U. Mass. Lowell)

Introduction
The DASCH project (Digital Access to a Sky Century at Harvard) is a project that aims to digitize the ~530,000 photographic plates stored at the Harvard College Observatory that were obtained with various telescopes from 1885 to 1992 [1]. The plates cover the whole sky and provide typically 500 to 1000 measures of any object brighter than the detection limit, of typically 14 to 17 B magnitude. We developed a specific Pipeline [1,2] to process the plates and store those measurements in a database (See the poster of Los et al., this conference, for the description of the Pipeline). In order to extract the long-term (over 100 years!) light-curves of an object without confusion, one requirement is to obtain good astrometric solutions. An accuracy of 1 arc second (\(\alpha\)) or lower generally allows us to uniquely associate an object with its entry in the GSC 2.3.2 catalog, or to classify it securely as a new transient event. In practice, the scale of the plates varies from sub-arc-second to about 6\(\alpha\) per pixel depending on the plate series and we expect to reach a position accuracy lower than a 3 pixels limit (radius used for cross-correlations).

Distortions from the original telescope optics can have dramatic effects (offsets of up to a few arc minutes) on the edges. We implemented a 3 step procedure that allows to find the plate center blindly and ultimately correct the distortions of the plates.

1/ First guess
- Get pointing, scale, and orientation
- Observation log books not reliable
- Need to find a solution blindly, by pattern matching of bright stars with a reference catalog

2/ Refining the solution
- First guess is too crude to match the detected objects
- WCSTools [4] imwcs is used iteratively to reach a more precise solution
- Tycho 2 catalog is used with coordinates corrected for proper motions
- 10-20\(\alpha\) precision

3/ Fitting the distortions
- Objects are detected with SExtractor [5]
- 10,000 brightest sources selected
- A reference catalog is extracted from UCAC3 [6]
- Best astrometric reference (0.015 to 0.100\(\alpha\))
- Best proper motions (important for 100 years scale)
- 10,000 brightest objects in the field
- UCAC3 is filtered to remove its known biases:
  - Keep objects with 2MASS counterparts only
  - Cuts at 8-16 magnitude
- SCAMP [7] returns a 6th order polynomial fit stored in the header of the plate image file (step initially performed with IRAF/ccmap)

Results
- Test performed on 140 plates chosen randomly from different plate series
- 79\% of the plates were correctly processed
  - Mean error well below the 3 pixels limit and close or lower than 1\(\alpha\)
  - 44\% have better accuracy than with the previous version of the Pipeline
  - See the 4 examples on the right of the poster.
- 6\% of the plates show holes or have fewer reference stars
  - Lower accuracy
  - Example A: cloud reported in the log book
  - Example B: saturation in the center, the plate needs to be rescanned
- 15\% of the plates could not be corrected
  - Erratic distortion maps (see examples C and D)
  - Problem in imwcs, initial astrometry too uncertain for SCAMP to work

Conclusion
The DASCH Pipeline with SCAMP performs a precise astrometric correction of the scanned photographic plates. This is now the standard process. We expect that additional plates will be available and useful for lightcurve extraction.

Distortion maps for 4 selected plates. Those figures show the reference stars in RA/Dec with a color corresponding to its position error on the plate in arc seconds.

Position error vs offset for each reference star. Red: before correction. Green: previous pipeline. Blue: SCAMP (new Pipeline)


DASCH is supported by NSF grants AST-0407380 and AST-0909073
Visit the DASCH website at http://hea-www.harvard.edu/DASCH

References: