Correcting the Astrometry of DASCH scanned plates

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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 (") or lower generally allow 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" 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 **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
- **Astrometry.net** [3] procedures are optimized for this, and are integrated since June 2008
- 99.75% success
- low precision

2/ Refining the solution

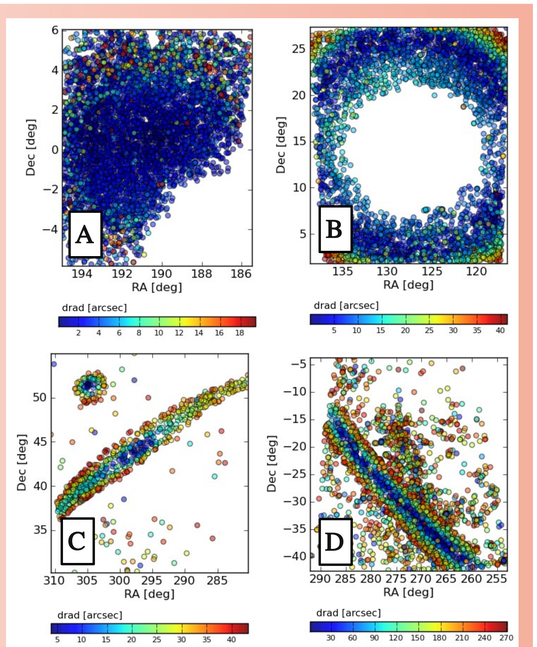
- First guess is too crude to match the detected objects
- **WCSTools** [4] *imwcs* is used iteratively to reach a more precise solution
- Tycho 2 catalog is used with coordinates corrected for proper motions
- **10-20" precision**

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")
  - ✔ 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"**
  - ✔ 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



Erratic distortion maps before SCAMP

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.

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

References: **[1]** Grindlay et al. 2009, ASPC, 410, 101 **[2]** Laycock et al. 2010, AJ, 140, 1062 **[3]** Lang et al., 2010, AJ, 137, 1782 **[4]** Mink 2002, ASPC, 281, 169 **[5]** Bertin & Arnouts 1996, A&AS, 317, 393 **[6]** Zacharias et al. 2009, ApJ, 139, 2184 **[7]** Bertin 2006, ASPC, 351, 112

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.
Left: before correction
Right: after SCAMP correction

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

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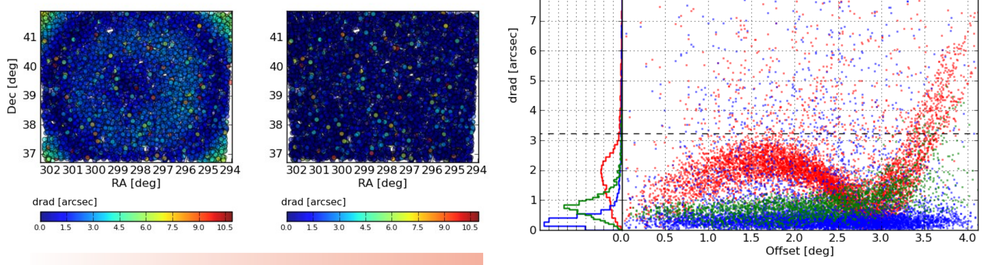

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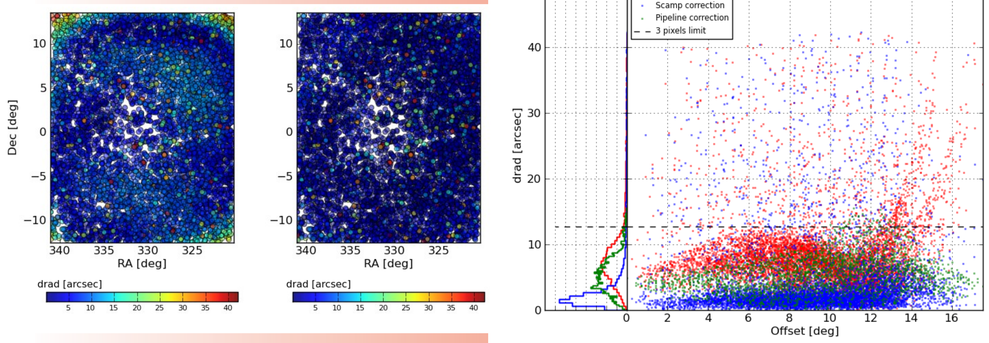
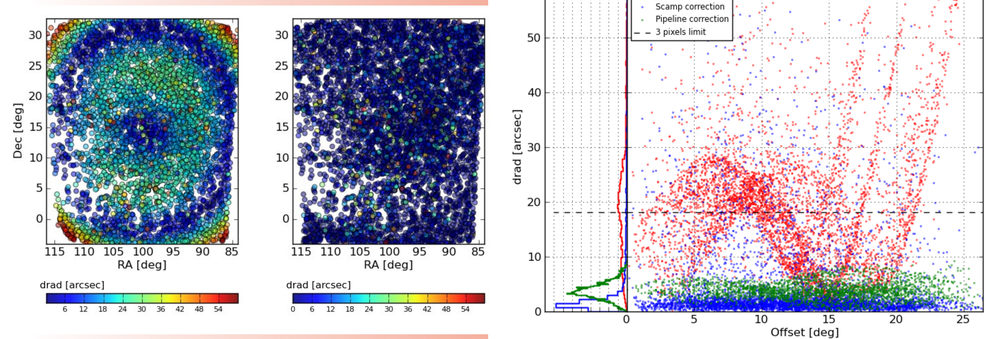


DNB 04504



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