Automatic Georeferencing of Astronaut Auroral Photography: Providing a New Dataset for Space Physics

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http://cosmos.esa.int/arrrgh

Motivation

ISS astronauts have taken tens of thousands of auroral photographs[1] in high temporal (1s) and spatial (≈10″/px) resolution.

Their use in research though is limited as they often lack accurate orientation, scale, and timestamp information.

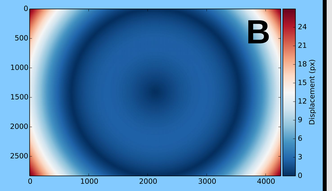
The goal of this project is to reconstruct these data as accurately as possible for images containing a clear starfield (A).

Full automation is mainly hindered by the difficulty of timestamp correction.

Step 1: Lens Distortion Correction

Uniform accuracy requires that the lens distortion (B) is corrected (cf. Step 3).

We use the open-source *Lensfun*[2] database and library for that purpose.



Step 2: Starfield Masking

We reconstruct the orientation and scale of an image using its starfield.

Masking is necessary to avoid too many false positives in the star extraction phase during Step 3.

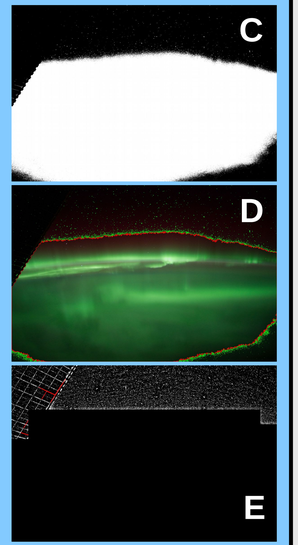
Approach: Detect non-starfield areas:

C) Histogram peak-based thresholding

D) Contour detection using C
→ Block-masking of big contours

E) Adaptive thresholding & line detection
→ Mask remaining dark artificial structures

F) Result, here displayed with high contrast



Step 3: Astrometry

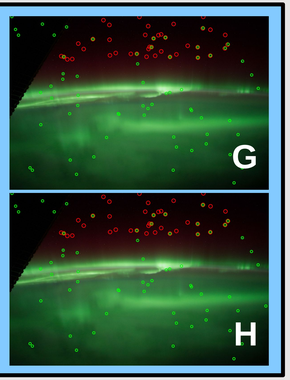
We use *Astrometry.net*[3] to identify the stars and hence determine orientation and scale.

G) Solution without distortion correction

H) Solution with distortion correction

Red = stars extracted from image

Green = reference catalogue stars



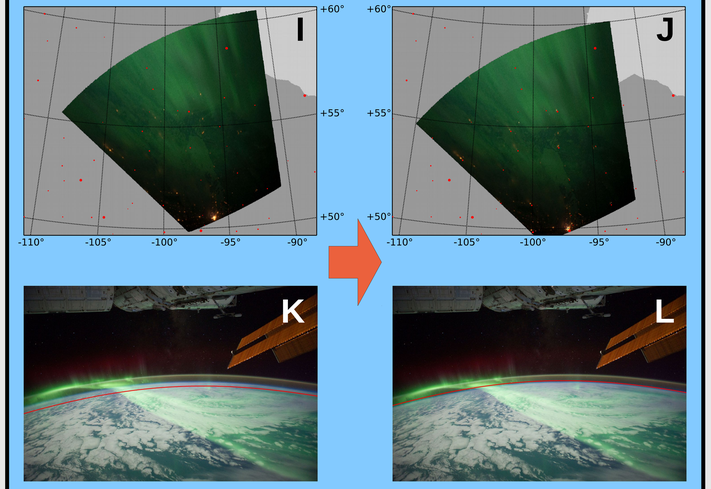
Step 4: Timestamp Correction

We use the timestamp of an image to locate the ISS. Together with orientation and scale we calculate the latitude and longitude of each pixel at 110km altitude.

Problem: Camera times were found to be off by up to around **1min**. Ideally, we need **<1s** precision.

Manual timestamp correction *once* per image sequence (≈ 500 images):

We use city lights for accurate timestamp correction by comparing them visually with reference data[4] (Δ I,J = -13.5s). If no city lights are visible we use the horizon of the earth for rough corrections (Δ K,L = -28.5s) – **if the horizon is covered by aurora, then no correction is possible**.



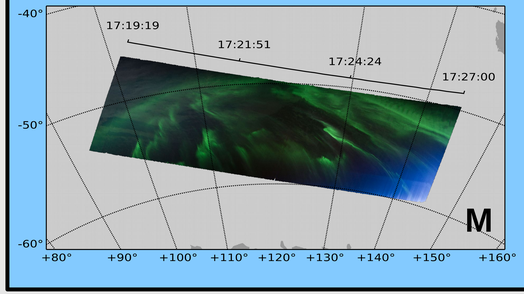
Conclusions

We developed a (semi-)automatic method for georeferencing astronaut auroral photography.

Due to inaccurate timestamps the achievable accuracy varies depending on whether city lights, the horizon or neither are visible.

This new dataset (to be released) provides potential for multi-point observations of the aurora borealis and valuable southern hemisphere coverage (M).

The project website (**http://cosmos.esa.int/arrrgh**) will provide a continuously updated time and location-searchable database of georeferenced auroral images.



Acknowledgements & References

1. ISS images courtesy of the Earth Science and Remote Sensing Unit, NASA Johnson Space Center (http://eol.jsc.nasa.gov).

2. Lang, D., Hogg, D. W., Mierle, K., Blanton, M., & Roweis, S., 2010, Astrometry.net: Blind astrometric calibration of arbitrary astronomical images, The Astronomical Journal 137, 1782–1800 (http://astrometry.net).

3. Lensfun database and library, developed by the Lensfun open-source community (http://lensfun.sourceforge.net).

4. City locations and scales from Natural Earth (http://naturalearthdata.com).

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