P09

Streaks Detection Algorithm in Astronomical Images from the Tomo-e Gozen Camera at Kiso Observatory

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We have developed a streaks detection algorithm for images coming from the Tomo-e camera of the 1M telescope at Kiso Observatory. It follows a computer vision approach, with the next stages: preprocessing, thresholding, Hough transform, and clustering of streaks. A set of artificial streaks were superimposed over real Tomo-e images, and with a background noise of the real frames estimated in 550 ADU, and a peak brightness of the artificial streaks ranging from 630 to 1150 ADU, all streaks were detected correctly. The algorithm took 0.52 seconds to detect 8 artificial streaks in one of the 84 image sensors, when running in a 1.1GHz dual core CPU processor with RAM 8 GB. Real images will be tested at a later stage. The Tomo-e camera survey has a minimum time between frames of 6 seconds, which corresponds to 12 consecutive images of 0.5 seconds exposure each, for one particular region of the sky. Currently the algorithm is being exported to a GPU NVIDIA Quadro RTX 8000 dual system with 144 multiprocessors, that will allow the algorithm to process in parallel over the 84 image sensors of the camera, with the aim to detect all streaks under 6 seconds.

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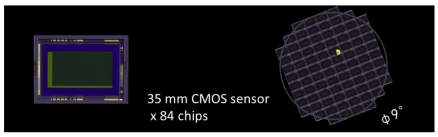
We have developed a streaks detection algorithm for images coming from the Tomo-e camera of the 1M telescope at Kiso Observatory. It consists in three stages: preprocessing (removal of stars), detection (based in Hough transform) and analysis (photometry, astrometry and TLE database matching). The detection stage is run in a 4 x GPU NVIDIA Quadro RTX8000 system, allowing the algorithm to preprocess and detect streaks in each FITS file (~40 Mpixels) in ~100 ms.

Tomo-e Gozen Camera



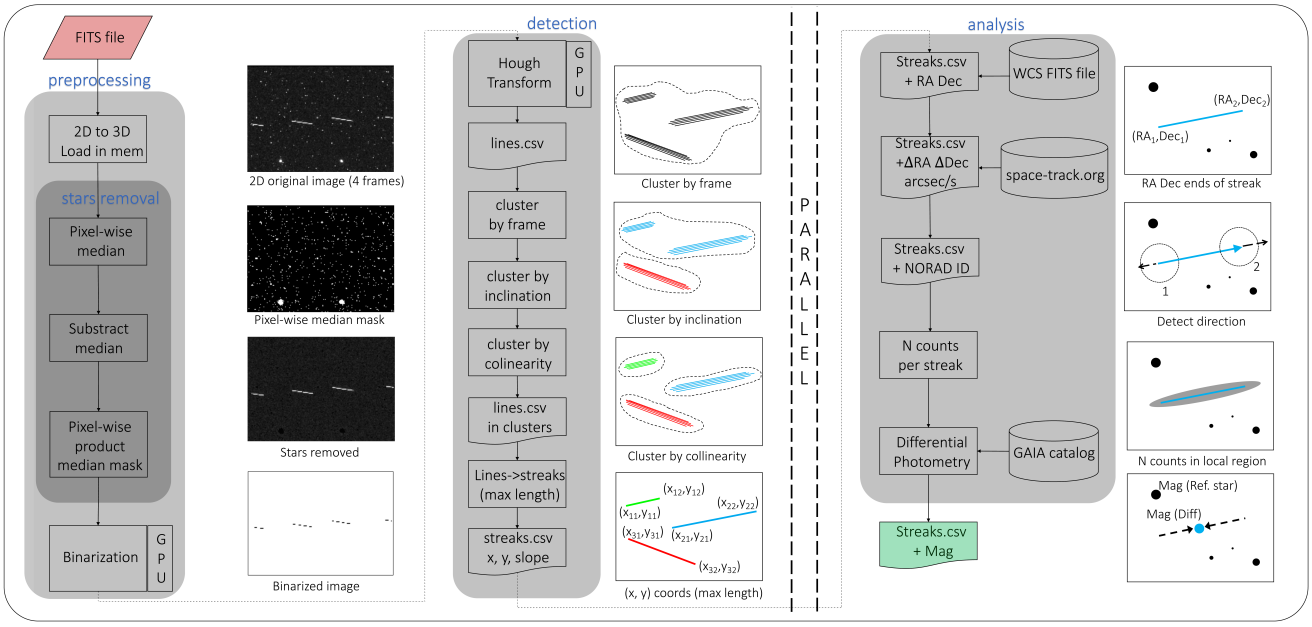
Array of 84 CMOS sensor covering FOV 9º diameter
credit: www.ioa.s.u-tokyo.ac.jp/tomoe

FITS : 2000 x 1128 x 18 = 40.6 Mpixels (162 MB)
Frame: 40.6 x 84 sensors ~= 3.4 Gpixels (13.6 GB)
Data rate: ~ 1.5 – 1.7 TB / hour (~20 s nudging time)

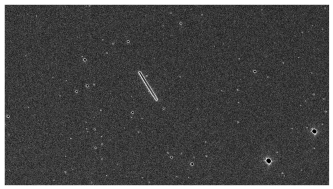
Features

- GPU system: 4 x NVIDIA Quadro RTX8000
- Preproc. and detection speed = ~100 ms per FITS file.
- Analysis speed = ~8-15 seconds per FITS file.
- Preprocessing and detection in PARALLEL analysis
- Orbital altitude (observation range 30º - 90º):
  - 550 km → 4200 km (one end within boundaries)
  - 1100 km → 4200 km (both ends within boundaries)
- Astrometry: - RA Dec coordinates of streaks ends.
  - Direction: RA Dec arcsec/s

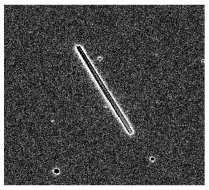
Process



Results



SL-8 R/B (NORAD 16766)



ZOOM SL-8 R/B (NORAD 16766)

- 21.084 FITS files analyzed ~ 3.4 Tbtyes
- 2 hours observation time processed in ~ 1 hour
- 85 FITS files with streaks detected
- 30 out of 35 objects identified (83%)

Conclusions and next steps

- **Fast system**: ~100 ms detection and 8-15s analysis -> **Real-time**
- Detect RA Decs of streak ends -> **accurate astrometry**
- Sensitivity: Detect objects down to **+11 Mag**
- **Identification**: matching with space-track.org **elsets database**

- **Increase sensitivity**: stacking method (Yanagisawa, Trans. Japan Soc. Aero. Space Sci.Vol. 44, No. 146, pp. 190–199, 2002)
- **Increase orbital altitudes**: detect streak ends in different sensors

Acknowledgements

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