ÖAW IWF

SPACE DEBRIS LASER RANGING

Automated space debris observation and detection with a low cost astronomy mount

© Dr. Christian Kettenbach, Daniel Fauland

Michael Steindorfer, Franz Koidl, Peiyuan Wang, Daniel Fauland, Nadine Trummer, Sebastian Schneider
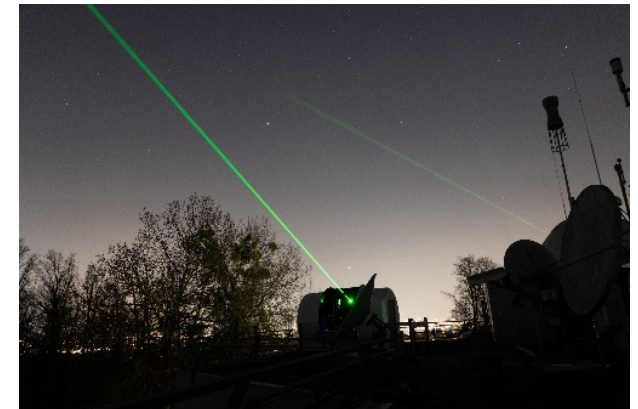1) Space Research Institute, Austrian Academy of Sciences

MAIN INGREDIENTS

The main ingredients

- Mount: 359 €
- Tripod: 126 €
- Camera: 219 €
- Dew heater: 50 €
- Camera lens: 150 €
- Python: 0 €
- Location: e.g. Lustbühel roof
- Laptop: There might be someone having one...

Overall: 904 €

Add-On: Plate Solving License: 150 €

What do we want to do with it?

Versatile image detection tool for SLR and SDLR applications

- Visualize space debris and satellites (day and night)

- Automated target detection
  - 2 operation modes: staring mode = moving target / tracking mode = fixed target)

- Time bias and across track bias calculation

- ASCOM-based mount control -> flexibility

- ASI Camera control

- Automated scheduling

- Future: Automated pointing determination -> Concept in progress

PRELIMINARY SETUP

Test setup on roof of Lustbühel

- North-level adjustment: mobile phone
- Goto and center star -> approx. mount model completed

f = 50mm lens

3D-printed holders and dovetail

ZWO ASI camera

AZ-GTi GoTo WiFi

PROGRAM FEATURES

Multiple threads -> not interfering

1) Image read in

2) Image manipulation

- Auto. Thresholding: Histogram
- Satellite detection: Contour
- Active noise reduction

3) TLE download: spacetrack

4) Lagrange interpolation

5) Satellite position interpolation

6) Satellite scheduler

7) Mount control: ASCOM or read in (Contraves)

8) Future: (Plate Solving)

bias information

camera settings
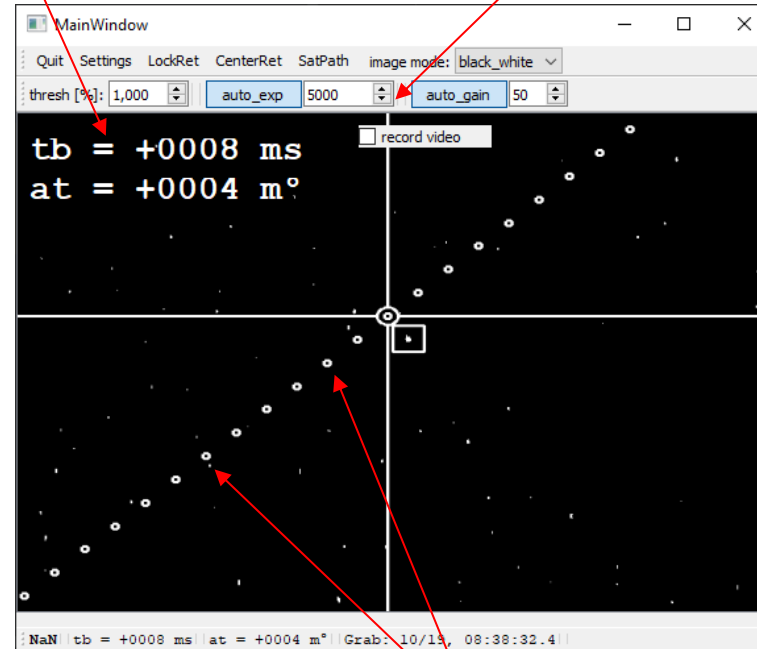
Predicted satellite path, $\Delta t = 100$ ms

1) dt = 0.02 sec, 50 fps

2) dt < 0.02 sec

3) dt = 6 hours

4) dt = 0.02 sec

MODE #1: STARE MODE

Scheduler

- Calculate passes of >300 debris targets
- Check when passes cross certain elevation

- Slew to az/el position e.g. 60 sec before
- Wait while satellite passes through FOV
- Measure for e.g. 120 sec
  - x /y position
  - az / el offset

- (Perform plate solving)

**Scheduler: Real-time video
elevation 45° –> 30° –>15° –> 60°**

id	norad	time	az	el	umb
C34	43207.0	-118.0	93.42	45.01	0.0
B07	19650.0	-58.0	156.30	44.24	0.0
269	20624.0	-28.0	358.58	44.13	0.0
B07	19650.0	107.0	64.23	44.07	0.0
G39	43687.0	122.0	111.29	45.04	0.0
269	20624.0	167.0	120.55	44.97	0.0
C47	44543.0	182.0	135.06	45.00	0.0

el pass [°] 45
dt_meas 120
d_slew [s] 60
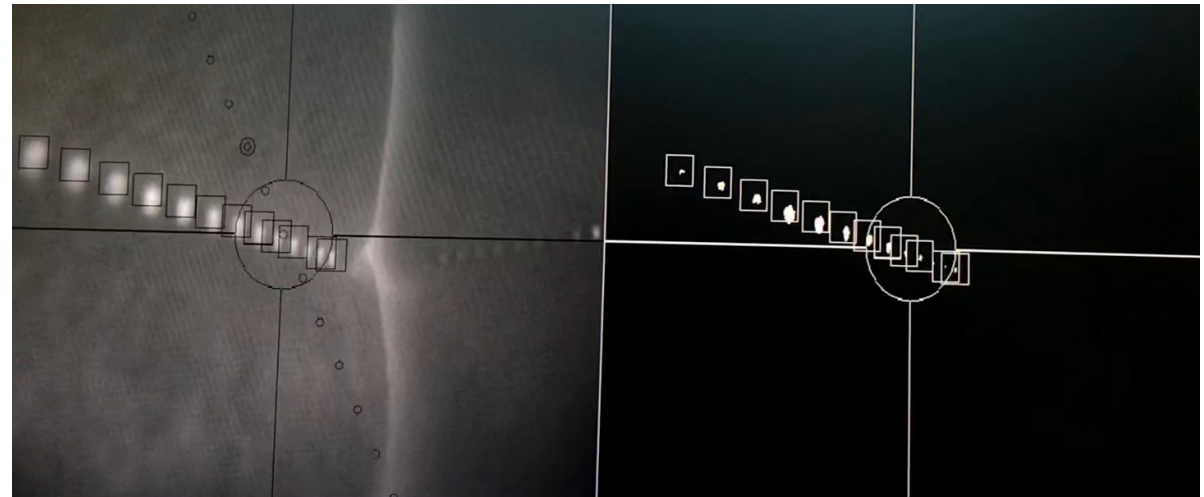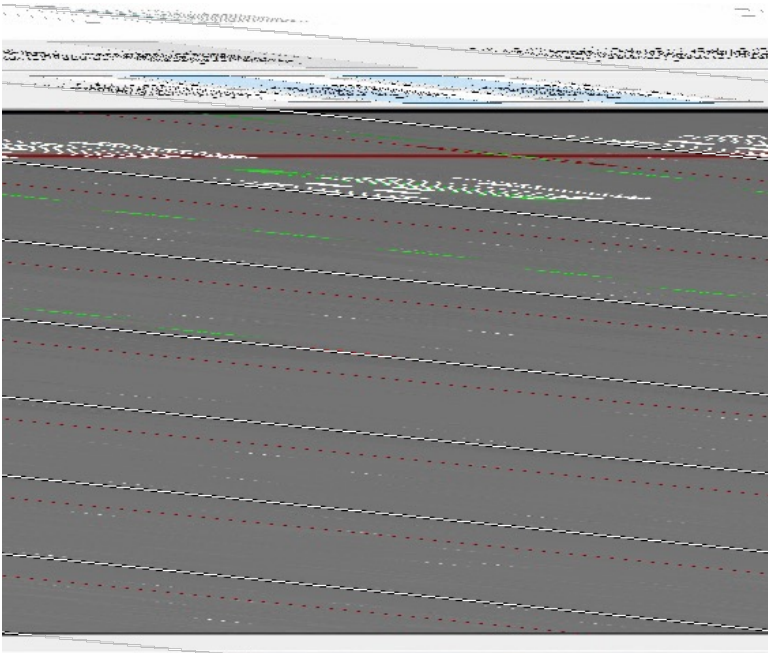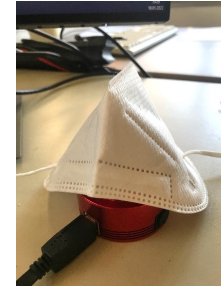dt_pred [s] 120
d_el [°] 3
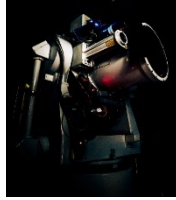
connect mount
disconnect mount
tracking off

MODE #1: STARE MODE

Satellite passage

- Left: Tandem X pass, Right: FFP2-mask test facility

- Automatic detection of (multiple) moving objects

- Green circles: predicted satellite pass (not needed in stare mode)

MODE #2: TRACKING MODE

Tracking of satellites

- Low cost mount: [˚/sec] -> LEO tracking hard

- Piggyback solution or better mount

- Three image modes

  - Original

  - Original + Overlay

  - Black & white + Overlay

- Time bias / across track bias calculation

- Reticle movable -> FOV adjust

- Threshold settings -> Histogram

  - % of histogram peak

Histogram threshold
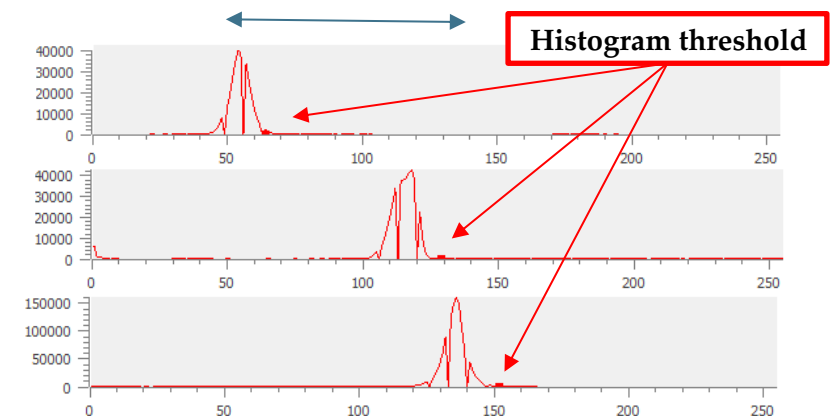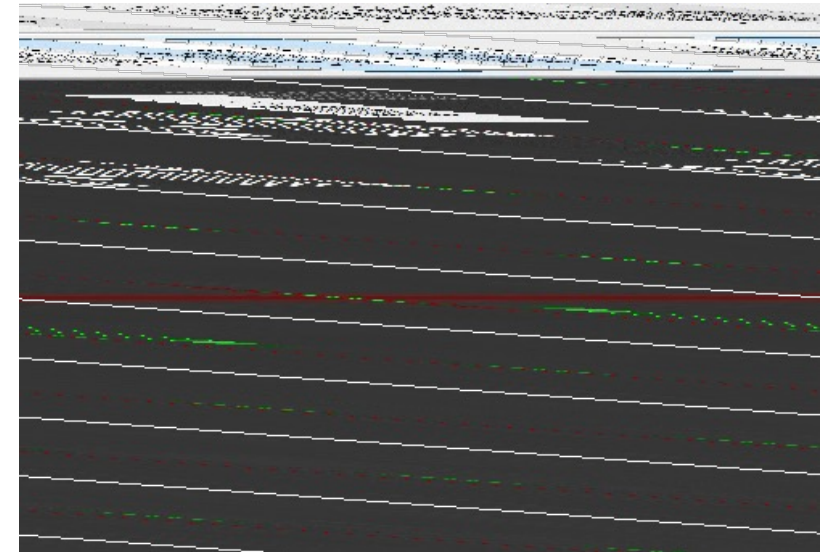
MODE #2: TRACKING MODE / BIAS

Low light detection examples:

- Hard to distinguish for human eye -> software reacts
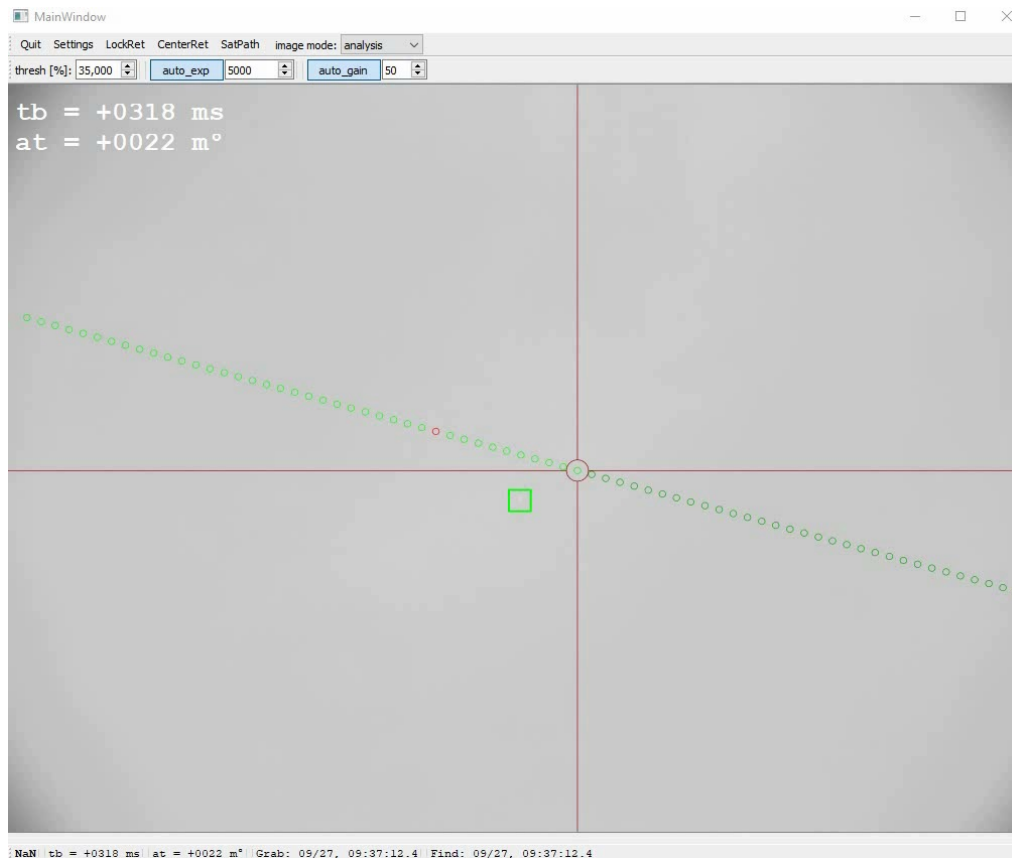
SUMMARY & OUTLOOK

Summary

- Satellite detection (moving, tracking)
- Time and range bias detection
- Satellite scheduler
- ASCOM-based mount control

Outlook

- Plate solving in routine operation
- Precise timing
- Cameras and objective tests
- Laptop -> Compact PC

!!! THANK YOU !!!