New Approaches: Optical, Image Processing and Computing

Daniel Topa
dantopa@gmail.com

University of New Mexico
Department of Mathematics and Statistics

September 17, 2024

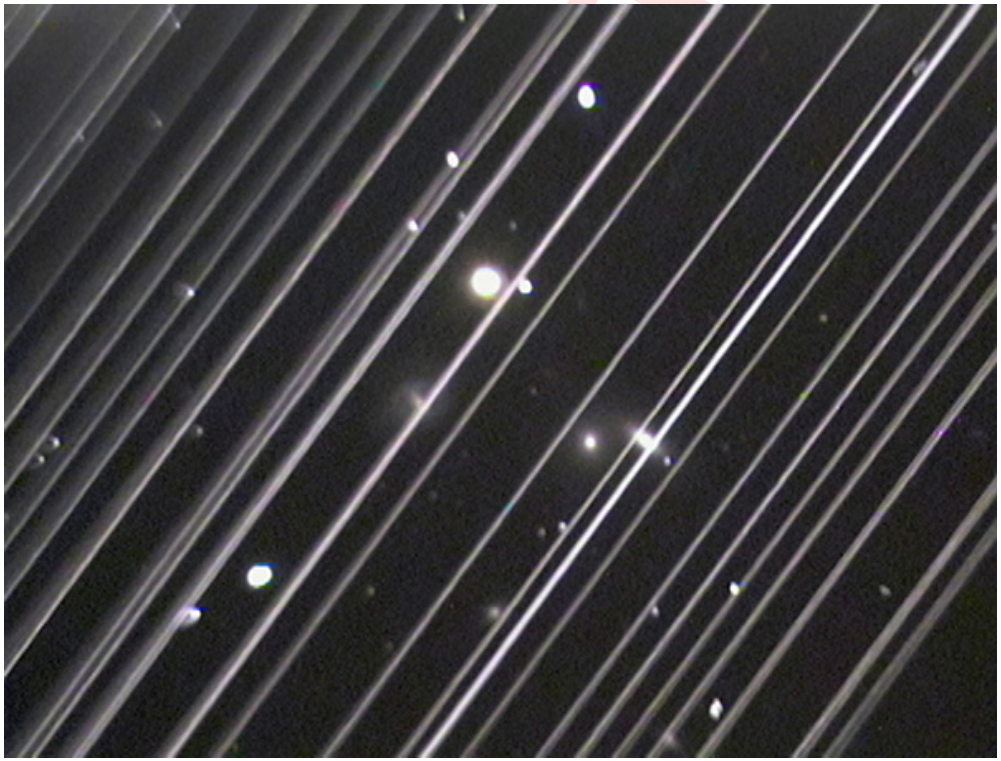
Overview

1. Open Source Photos
2. Open Source Software
3. Quo Vadis
4. Backup Slides

Survey of Open Source Satellite Streak Photos

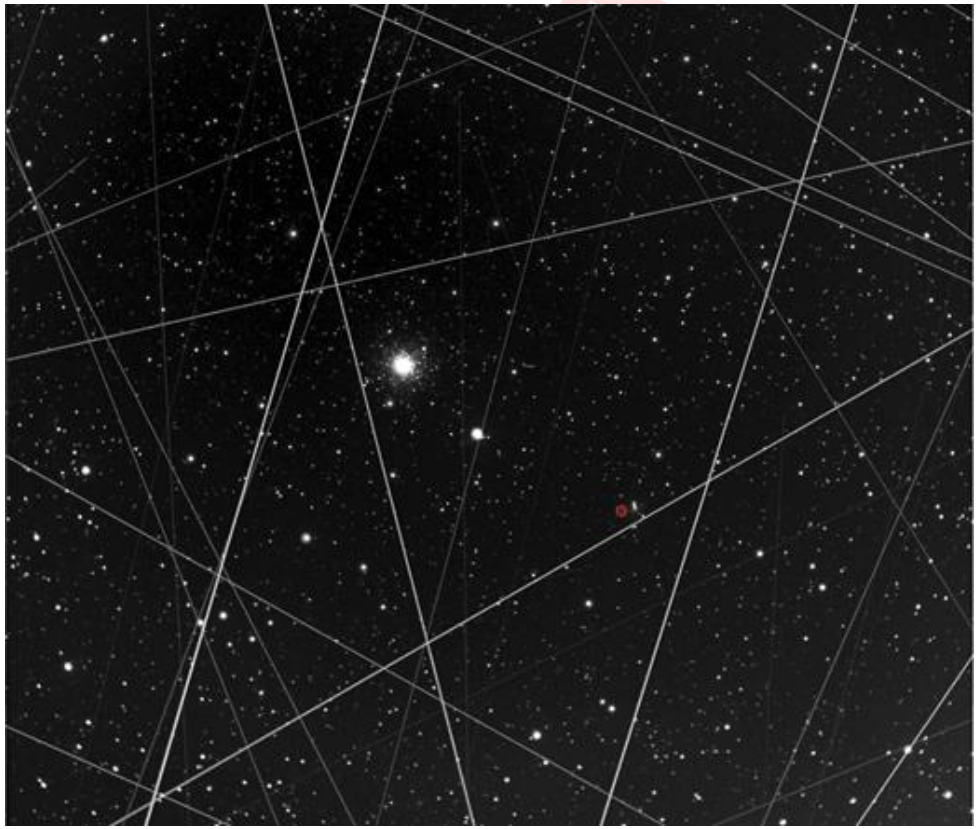
1. Media
2. Dedicated Web Sites
3. Federation of American Scientists

Physics Today– Starlink Streaks



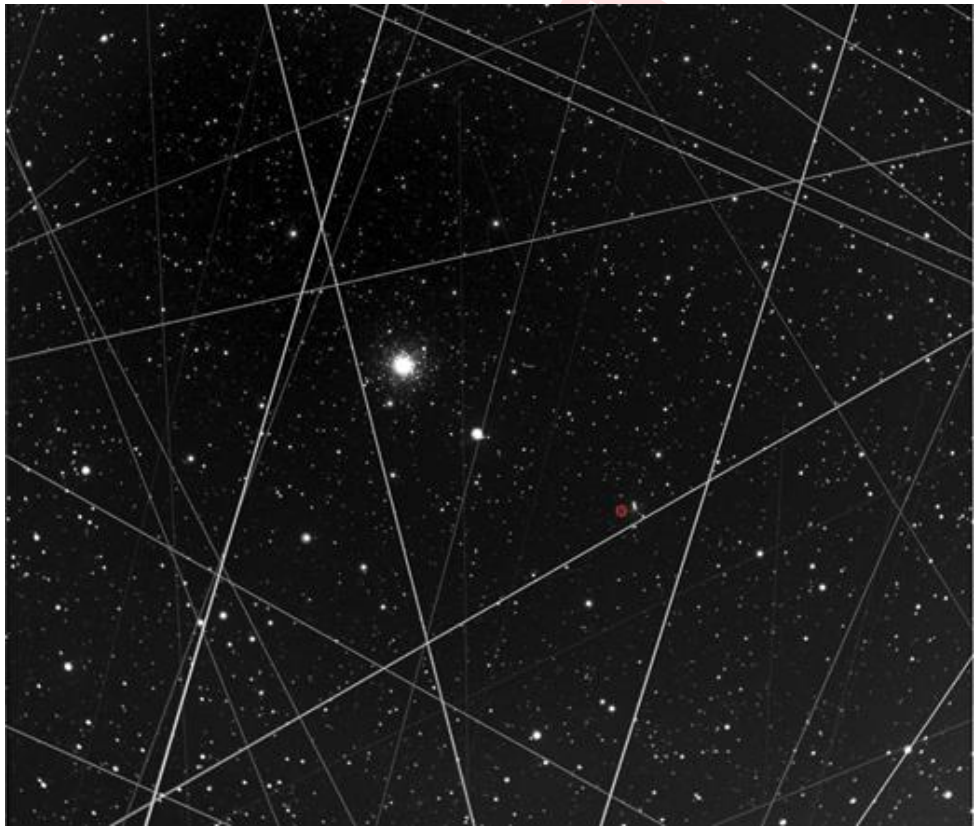
Streaks from sunlight reflected off Starlink satellites dominate this image from the Lowell Observatory. The satellites had not yet reached their operational altitude.

Physics Today – Crisscross Streaks



Satellite streaks crisscross a two-hour sequence of observations.
Near the center is a globular cluster and marked in red is a comet.

Physics Today – Crisscross Streaks



Satellite streaks crisscross a two-hour sequence of observations.
Near the center is a globular cluster and marked in red is a comet.

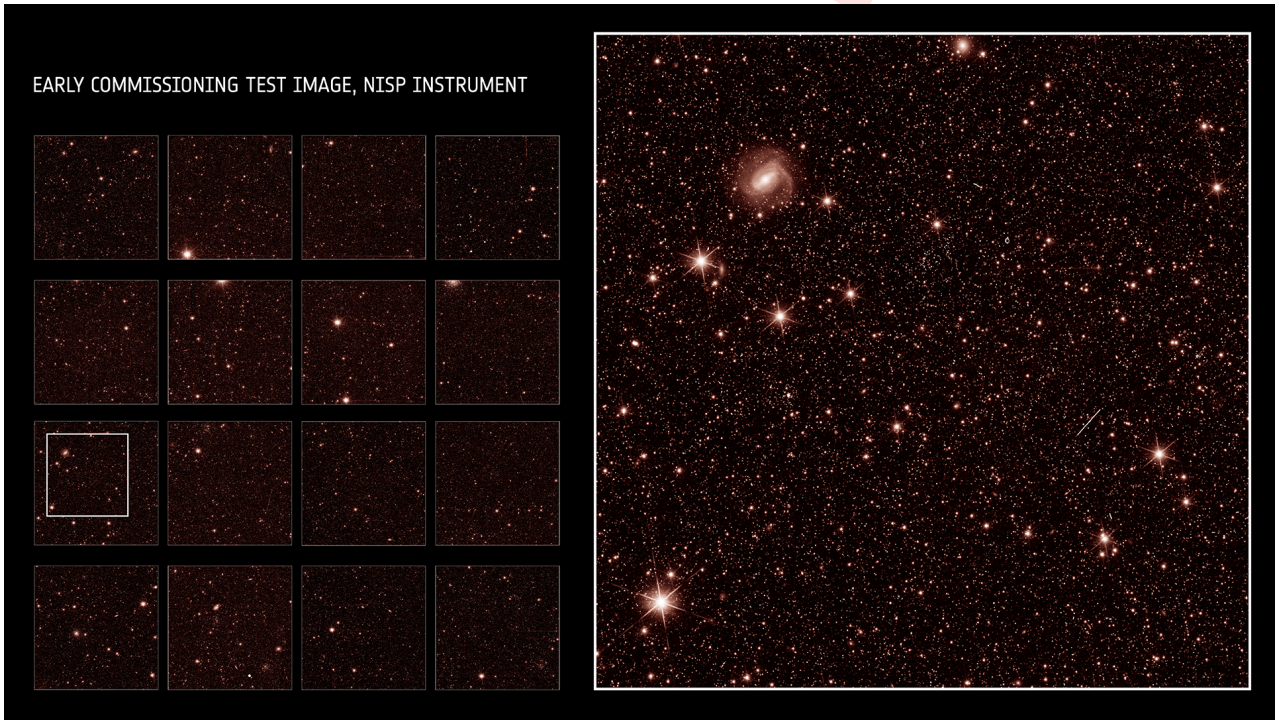
Scientific American – Can You Spot a Satellite?

Sunlight glinting off a satellite's solar panels can occasionally create visually stunning "flares"

Scientific American – Satellite Outshines Sky

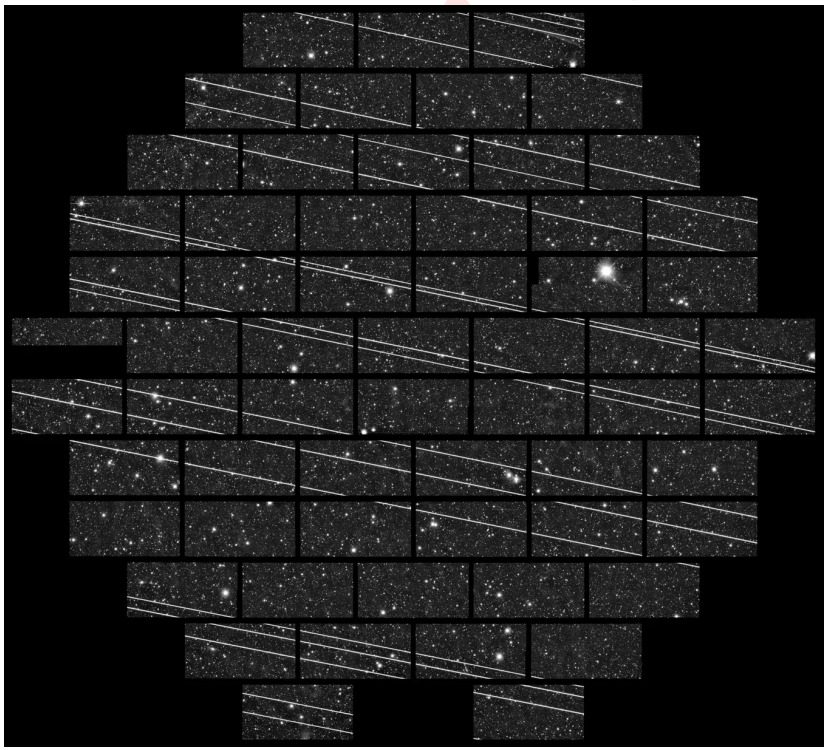
At times, the enormous BlueWalker 3 telecommunications satellite is brighter than some of the most iconic stars visible from Earth

Scientific American – Euclid Space Telescope



Euclid's telescope collected light for 100 seconds to enable NISP to create this image.

Scientific American – Dark Satellites Too Bright

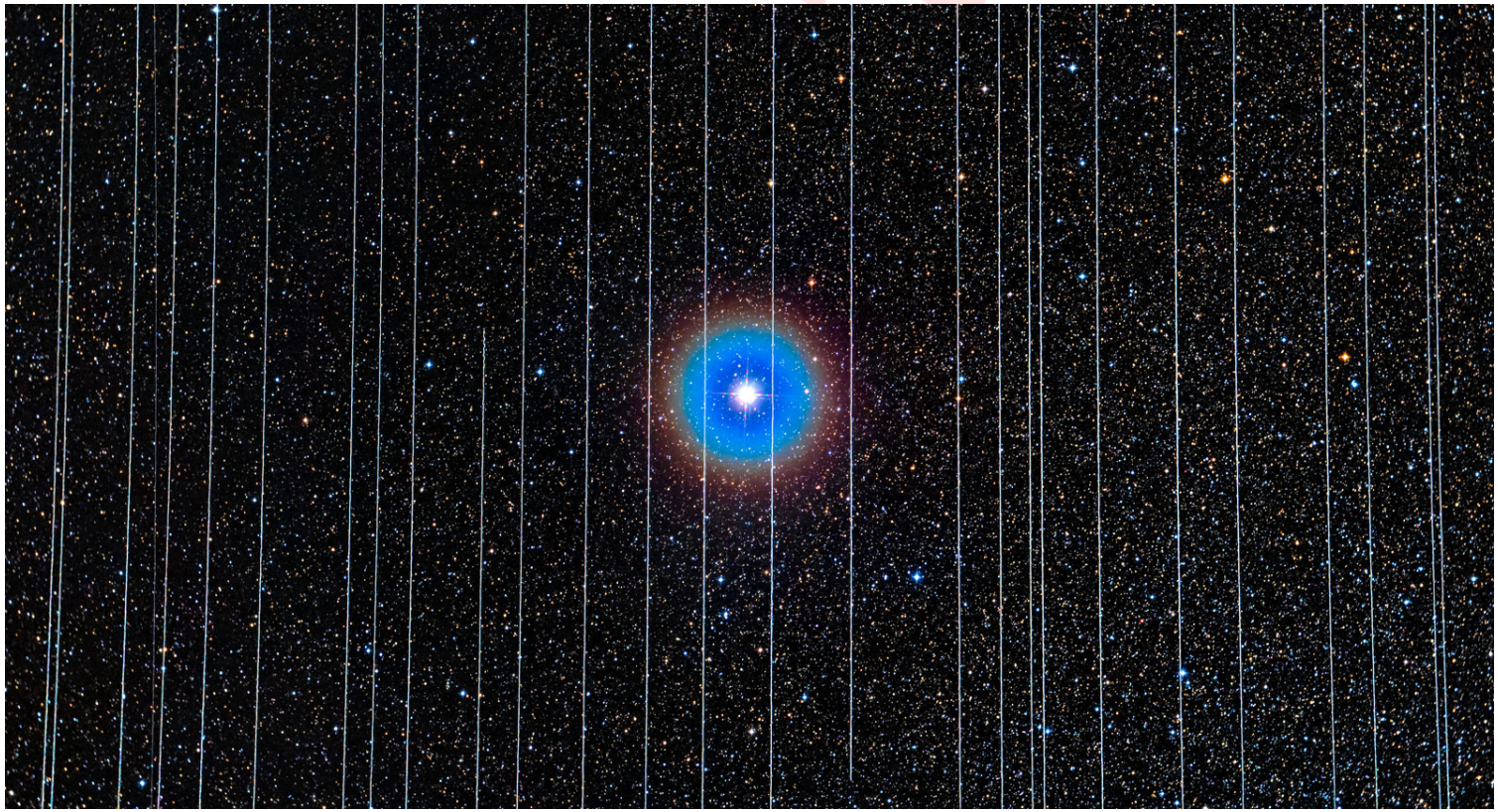


Time-lapse image of a Starlink satellite cluster at the Cerro Tololo Inter-American Observatory in Chile in November 2019 on the Blanco telescope's wide-field camera

Science – The Fault in Our Stars

Starlink satellite train over Cerro Tololo in Chile

Science – The Fault in Our Stars



The bright tracks of satellites in low-Earth orbit mar this 2.5-minute exposure of the double star Albireo

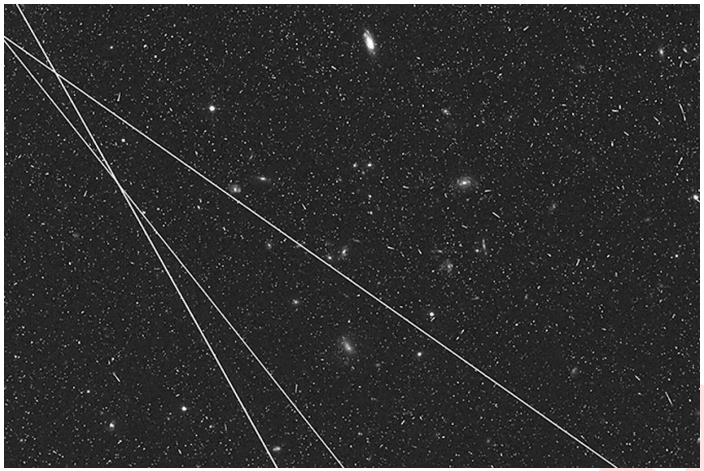
Science – The Fault in Our Stars

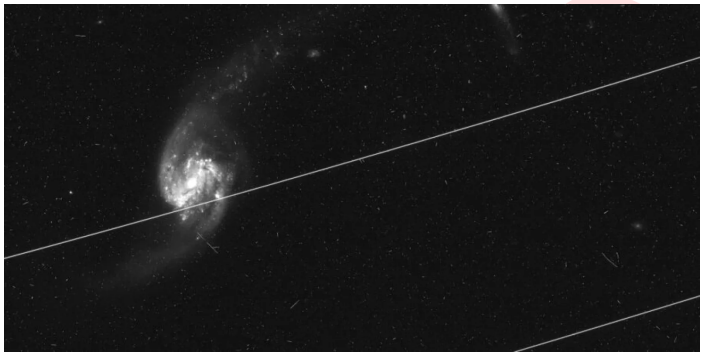
Starlink satellite tracks next to comet NEOWISE at Idaho's Craters of the Moon, a national monument. Fifty time-lapse shots, each 4 seconds long, were stacked to make the image.

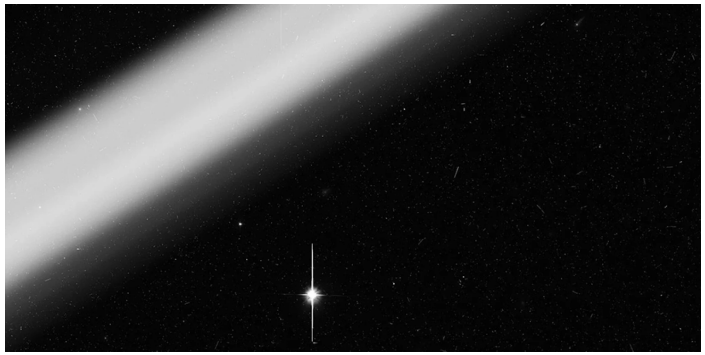
Science – Additional References

1. Astronomers set up center to counter threat of satellite swarms 3 Feb 2022
2. Tens of thousands of communications satellites could spoil view of giant sky telescope
3. Satellite swarm threatens radio array

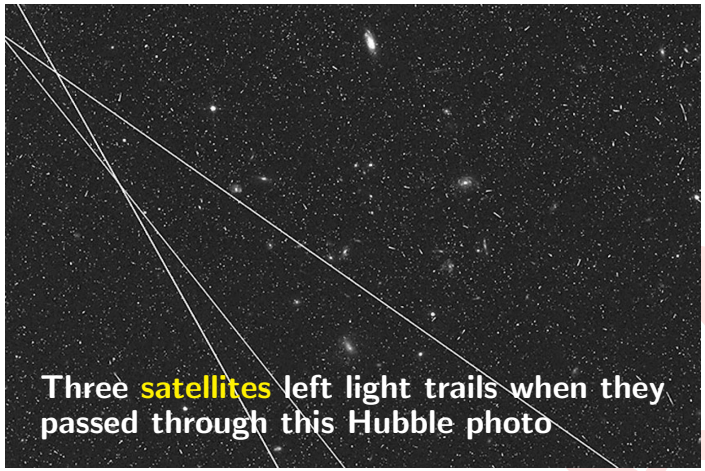
Duluth News Tribune







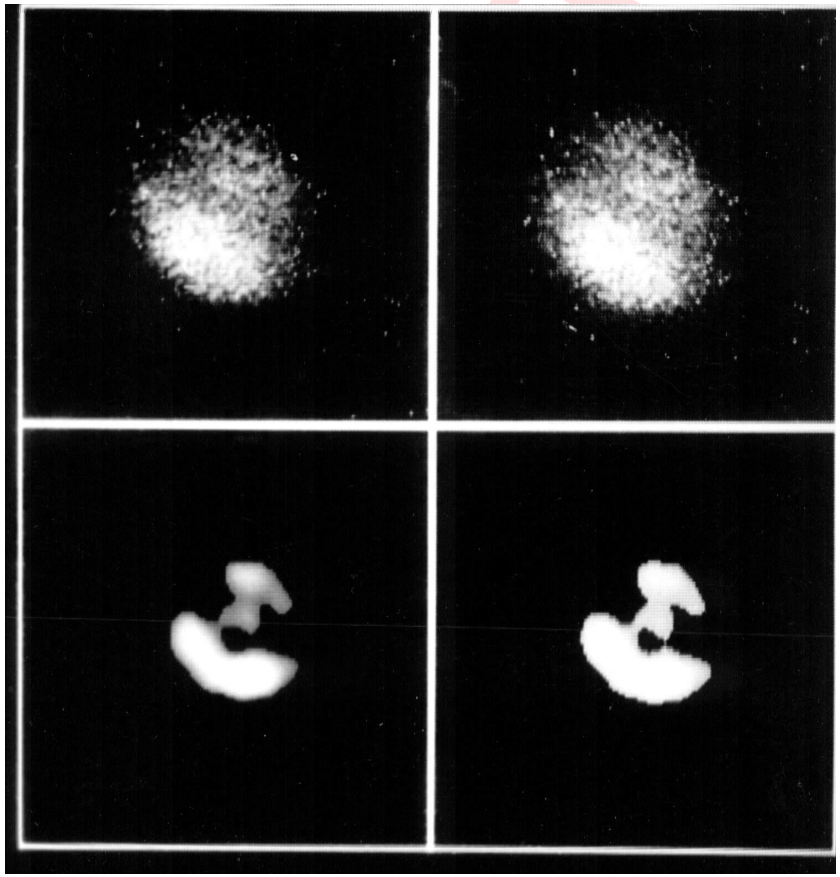
Duluth News Tribune



USAF Maui

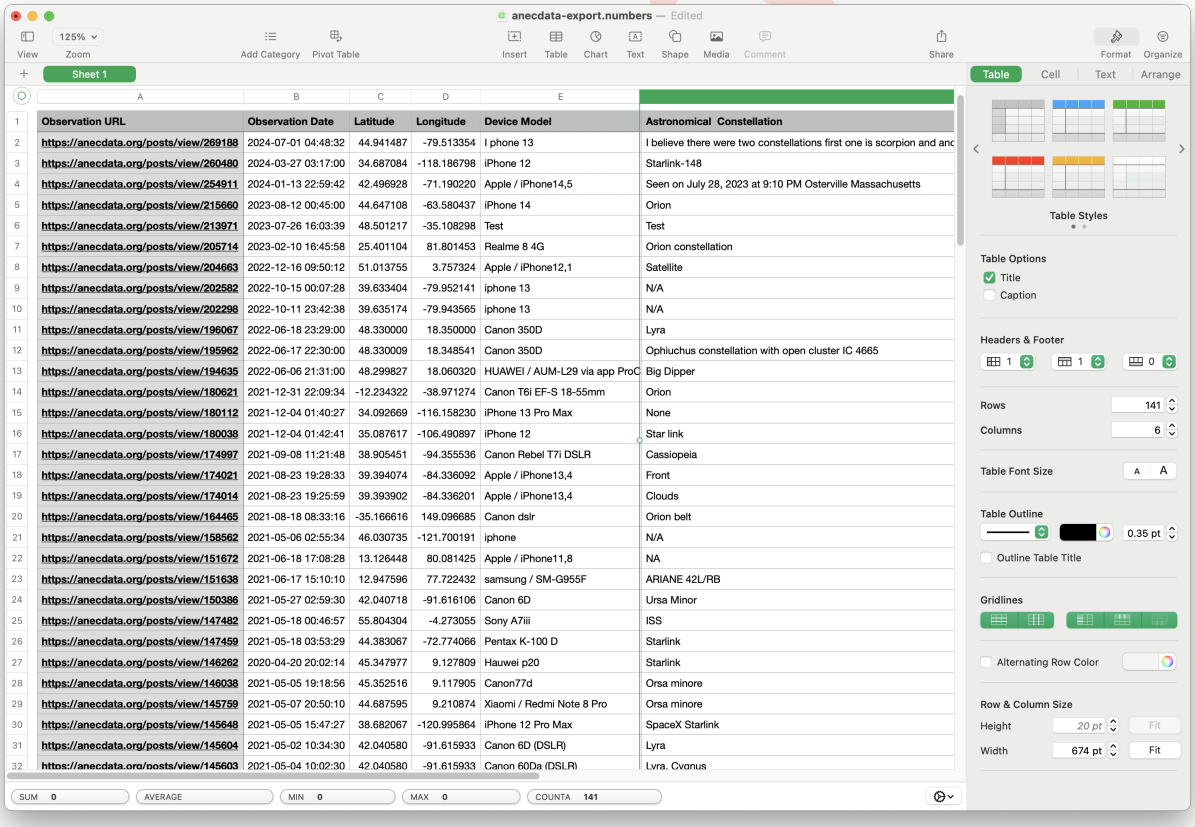
Space System – Lacrosse 1

https://www.satobs.org/seesat/Aug-2010/0037.html



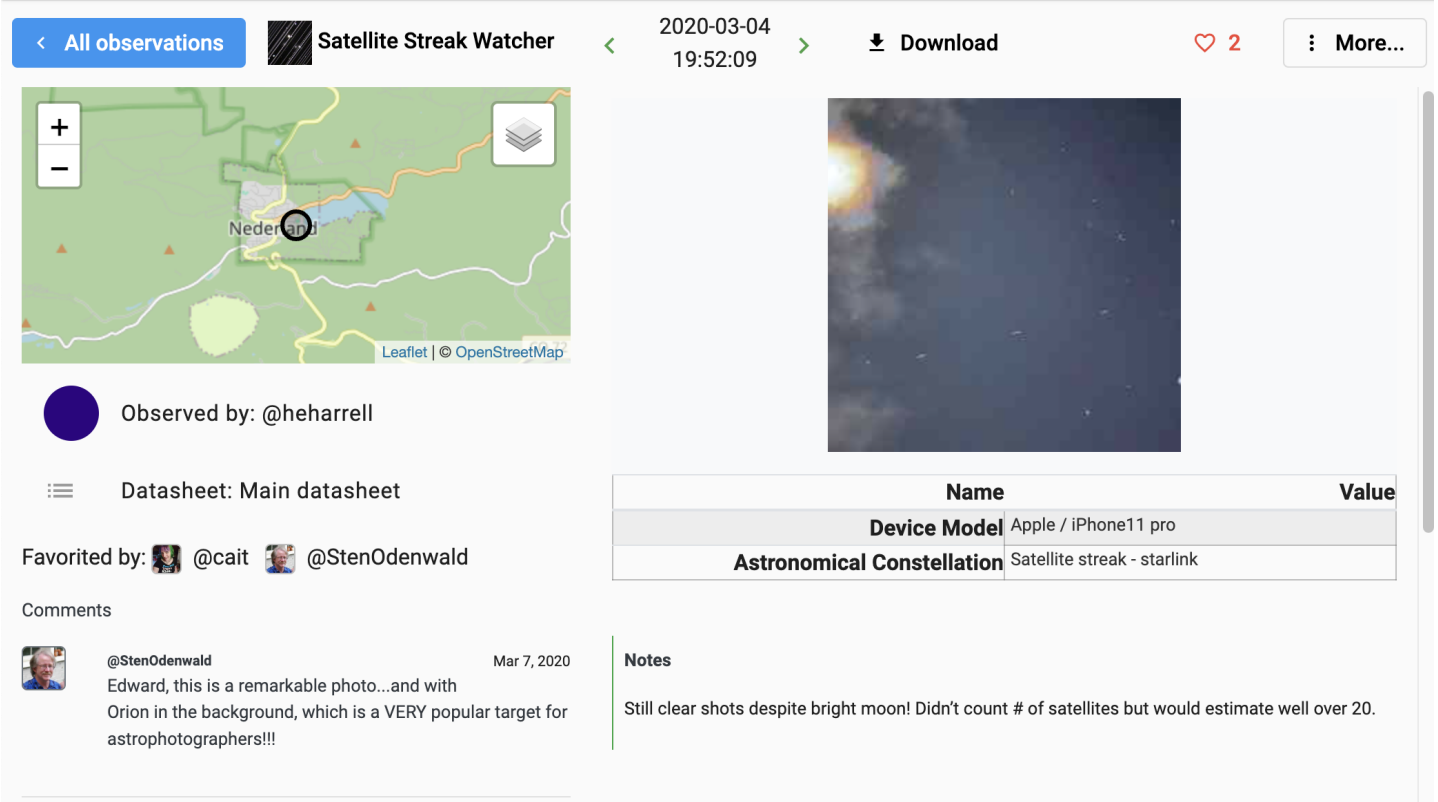
Satellite Streak Watcher

Satellite Streak Watcher: Data Base

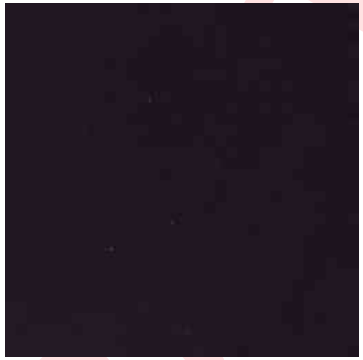


Observation URL	Observation Date	Latitude	Longitude	Device Model	Astronomical Constellation
https://anecdata.org/posts/view/269188	2024-07-01 04:48:32	44.941487	-79.513354	I phone 13	I believe there were two constellations first one is scorpion and anc
https://anecdata.org/posts/view/260480	2024-03-27 03:17:00	34.687084	-118.186798	iPhone 12	Starlink-148
https://anecdata.org/posts/view/254911	2024-01-13 22:59:42	42.496928	-71.190220	Apple / iPhone14,5	Seen on July 28, 2023 at 9:10 PM Osterville Massachusetts
https://anecdata.org/posts/view/215660	2023-08-12 00:45:00	44.647108	-63.580437	iPhone 14	Orion
https://anecdata.org/posts/view/213971	2023-07-26 16:03:39	48.501217	-35.108298	Test	Test
https://anecdata.org/posts/view/205714	2023-02-10 16:45:58	25.401104	81.801453	Realme 8 4G	Orion constellation
https://anecdata.org/posts/view/204663	2022-12-16 09:50:12	51.013755	3.757324	Apple / iPhone12,1	Satellite
https://anecdata.org/posts/view/202582	2022-10-15 00:07:28	39.633404	-79.952141	iphone 13	N/A
https://anecdata.org/posts/view/202298	2022-10-11 23:42:38	39.635174	-79.943565	iphone 13	N/A
https://anecdata.org/posts/view/196067	2022-06-18 23:29:00	48.330000	18.350000	Canon 350D	Lyra
https://anecdata.org/posts/view/195962	2022-06-17 22:30:00	48.330009	18.348541	Canon 350D	Ophiuchus constellation with open cluster IC 4665
https://anecdata.org/posts/view/194635	2022-06-06 21:31:00	48.299827	18.060320	HUAWEI / AUM-L29 via app ProC	Big Dipper
https://anecdata.org/posts/view/180621	2021-12-31 22:09:34	-12.234322	-38.971274	Canon T6i EF-S 18-55mm	Orion
https://anecdata.org/posts/view/180112	2021-12-04 01:40:27	34.092669	-116.158230	iPhone 13 Pro Max	None
https://anecdata.org/posts/view/180038	2021-12-04 01:42:41	35.087617	-106.490897	iPhone 12	Star link
https://anecdata.org/posts/view/174997	2021-09-08 11:21:48	38.905451	-94.355536	Canon Rebel T7i DSLR	Cassiopeia
https://anecdata.org/posts/view/174021	2021-08-23 19:28:33	39.394074	-84.336092	Apple / iPhone13,4	Front
https://anecdata.org/posts/view/174014	2021-08-23 19:25:59	39.393902	-84.336201	Apple / iPhone13,4	Clouds
https://anecdata.org/posts/view/164465	2021-08-18 08:33:16	-35.166616	149.096685	Canon dslr	Orion belt
https://anecdata.org/posts/view/158562	2021-05-06 02:55:34	46.030735	-121.700191	iphone	N/A
https://anecdata.org/posts/view/151672	2021-06-18 17:08:28	13.126448	80.081425	Apple / iPhone11,8	NA
https://anecdata.org/posts/view/151638	2021-06-17 15:10:10	12.947596	77.722432	samsung / SM-G955F	ARIANE 42L/RB
https://anecdata.org/posts/view/150386	2021-05-27 02:59:30	42.040718	-91.616106	Canon 6D	Ursa Minor
https://anecdata.org/posts/view/147482	2021-05-18 00:46:57	55.804304	-4.273055	Sony A7iii	ISS
https://anecdata.org/posts/view/147459	2021-05-18 03:53:29	44.383067	-72.774066	Pentax K-100 D	Starlink
https://anecdata.org/posts/view/146262	2020-04-20 20:02:14	45.347977	9.127809	Hauwei p20	Starlink
https://anecdata.org/posts/view/146038	2021-05-05 19:18:56	45.352516	9.117905	Canon77d	Orsa minore
https://anecdata.org/posts/view/145759	2021-05-07 20:50:10	44.687595	9.210874	Xiaomi / Redmi Note 8 Pro	Orsa minore
https://anecdata.org/posts/view/145648	2021-05-05 15:47:27	38.682067	-120.995864	iPhone 12 Pro Max	SpaceX Starlink
https://anecdata.org/posts/view/145604	2021-05-02 10:34:30	42.040580	-91.615933	Canon 6D (DSLR)	Lyra
https://anecdata.org/posts/view/145603	2021-05-04 10:02:30	42.040580	-91.615933	Canon 60Da (DSLR)	Lyra, Cygnus

Satellite Streak Watcher: Datasheet

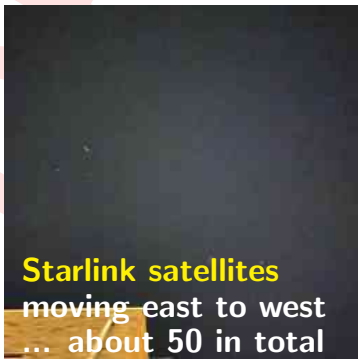


Satellite Streak Watcher: Photos

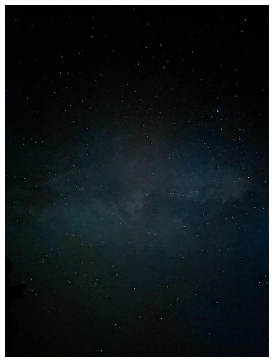





Satellite Streak Watcher: Annotations



Satellite Streak Watcher @StenOdenwald






Satellite Streak Watcher @StenOdenwald

StarLink satellites this morning between 5:24 and 5:38 am using my Galaxy S9Plus set at 10sec and ISO800

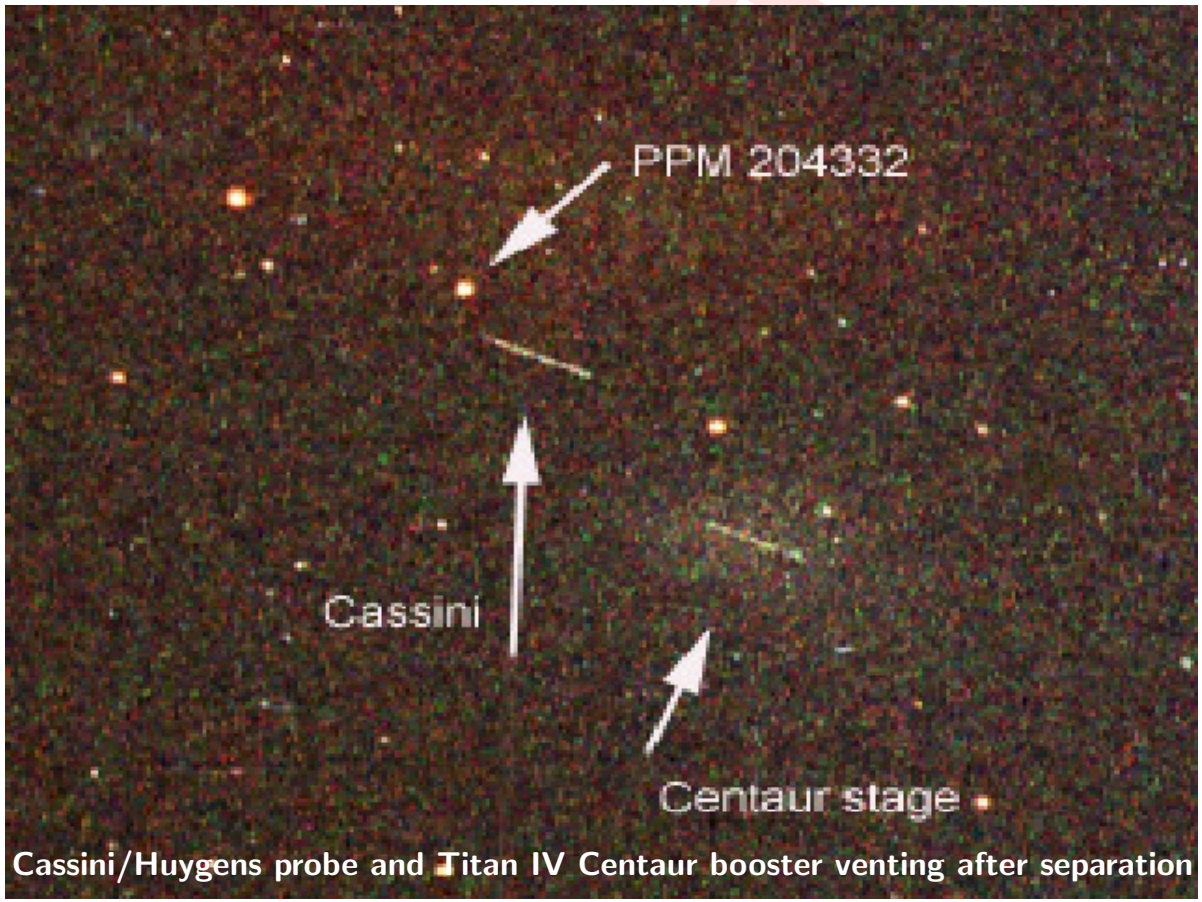
Gordon J. Garradd

Gordon J. Garradd

Comet Lovejoy, a meteor, a satellite and the Milky way 29/12/2011

Comet Lovejoy and tumbling satellite trail

Gorden J. Garradd



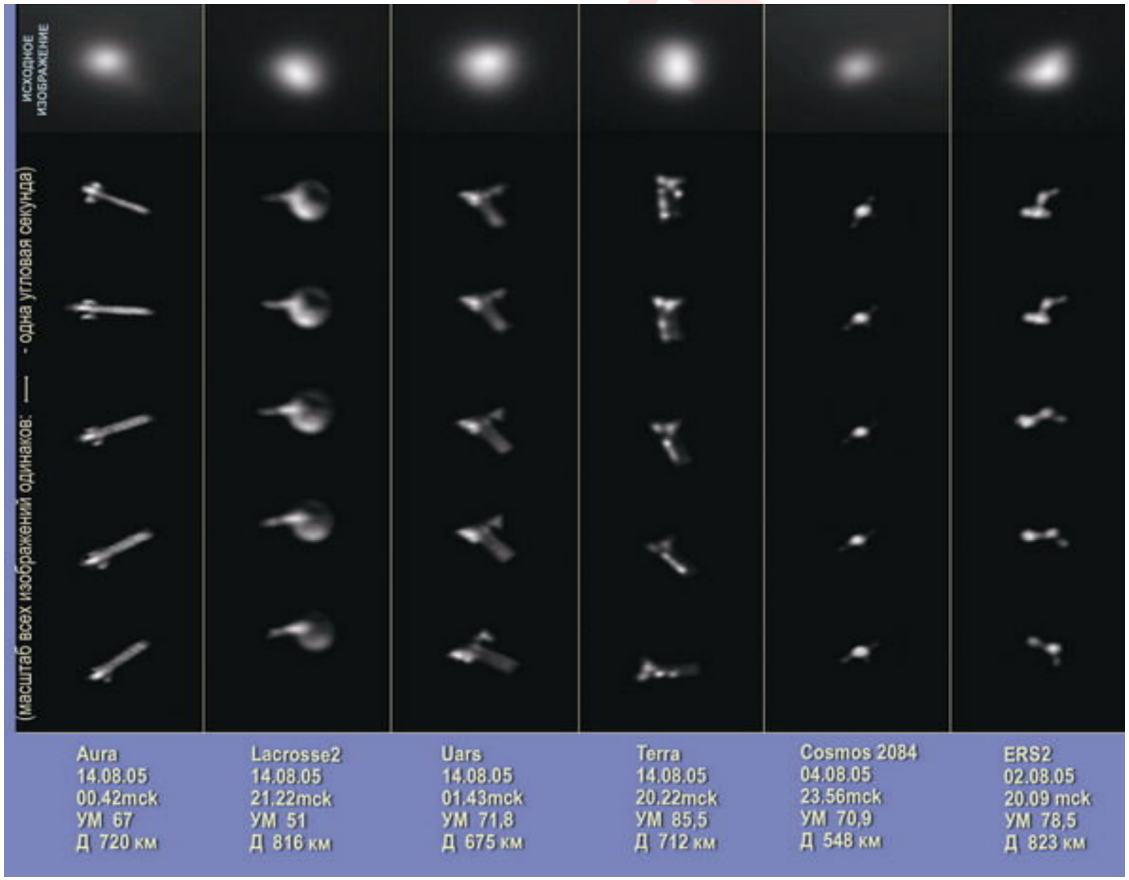
Cassini/Huygens probe and Titan IV Centaur booster venting after separation

Russian Photos – Adaptive Optics

Original images

One arc second

Images shown at common scale



Open Source

https://spp.fas.org

Open Source Image Analsis Tools

1. OpenCV
2. eVision
3. Scikit-Image
4. Astropy

OpenCV

1. World's biggest computer vision library
2. Python, C++ versions
3. Over 2500 algorithms
4. Operated by non-profit

eVision

Open eVision Libraries

1. Hardware-independent image processing and analysis libraries
2. Supports technologies such as Deep Learning and 3D
3. Sub-pixel measurement and calibration
4. 64-bit libraries

TensorFlow

1. Image processing in Python
2. High-quality, peer-reviewed code
3. Written by an active community of volunteers

Scikit-Image

scikit-image
image processing in python

1. Image processing in Python
2. High-quality, peer-reviewed code
3. Written by an active community of volunteers

Scikit-Image: Hough Transforms

Straight line Hough transforms

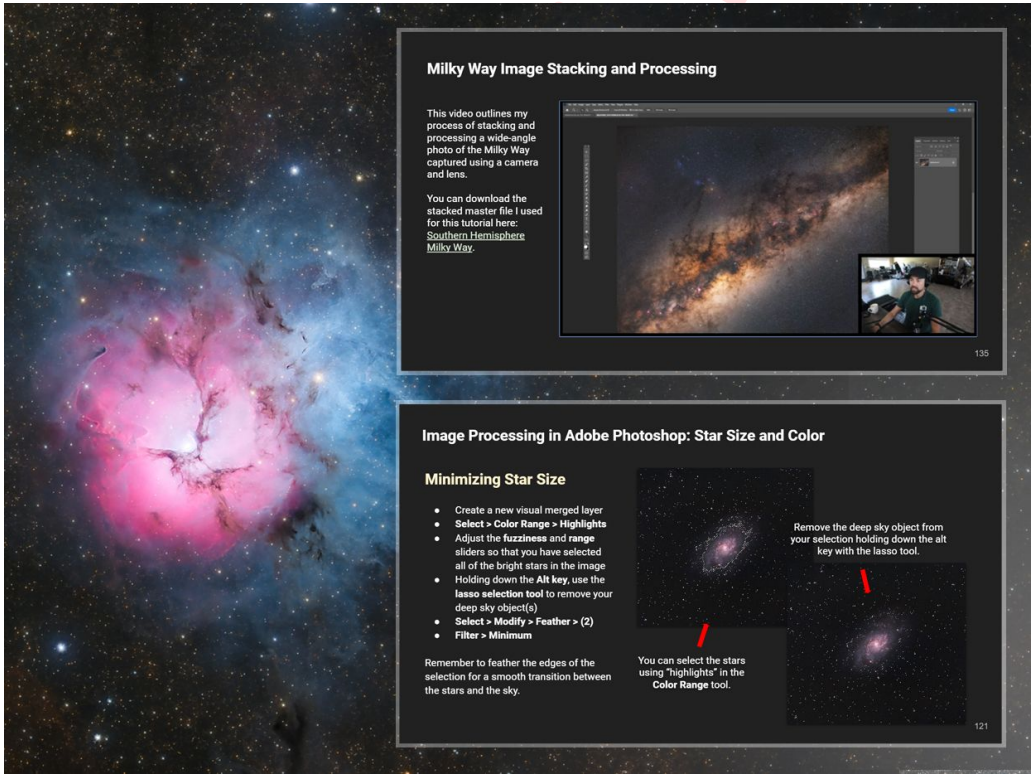
Astropy

1. Common core package for astronomy
2. Ecosystem of interoperable astronomy packages

AstroBackyard: Resources

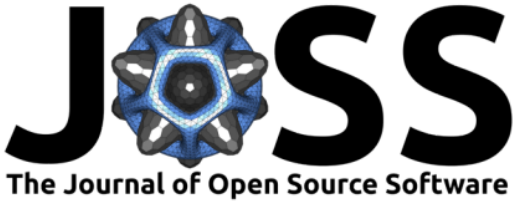
1. Common core package for astronomy
2. Ecosystem of interoperable astronomy packages

AstroBackyard: Image Processing Guide



Siril: Software

Siril: Functions



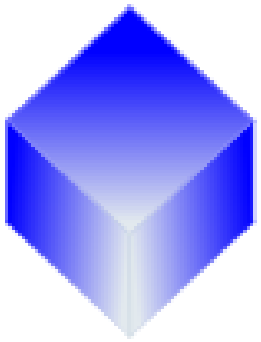
Siril: An Advanced Tool for Astronomical Image Processing

Cyril Richard[1], Vincent Hourdin[2], Cécile Melis[2], and Adrian Knagg-Baugh[3]

DeepSkyTracker

- Registering
- Stacking
- Simple post-stacking processes
- TIFF or FITS output

PixInsight



PixInsight

Powerful and specialised image processing software designed specifically for astrophotography

PixInsight Developer

- **PixInsight Class Library (PCL)**
- **PixInsight JavaScript Runtime (PJSR)**
- **PixInsight Open-Source Repositories at GitLab**

StarStax

StarStaX is a fast multi-platform image stacking and blending software, which allows to merge a series of photos into a single image using different blending modes. It is developed primarily for Star Trail Photography.

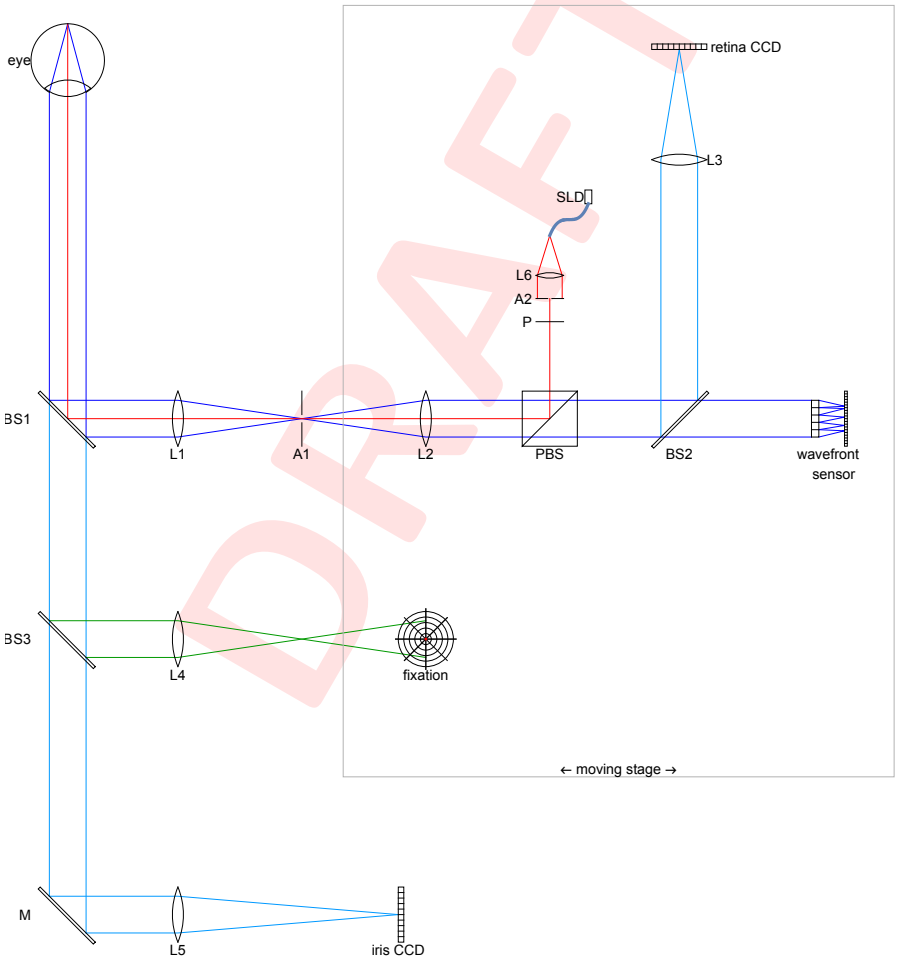
What Might We See?

1. Glinting
   - Reorientation
   - Orbit Maneuvers
2. Venting
3. Stellar obscuration
4. Collision
5. Satellites orbiting satellites

Possible Imaging Techniques, Methods, & Issues

1. Optical Phase Imaging
2. Hyperpsectral Imaging
3. Multiple Time Scales
4. Atmospheric propagation models

We Can Draw Optical Layouts



NVIDIA RTX

1. NVIDIA RTX Technology (NVIDIA)
2. NVIDIA RTX Platform (NVIDIA)
3. RTX Technology (NVIDIA)
    1. RTX Path Tracing
    2. RTX Global Illumination
    3. RTX Dynamic Illumination
    4. Deep Learning Super Sampling
    5. Real-Time Denoisers
4. Nvidia RTX (Wikipedia)

Image Processing with MPI–CUDA

Journal of Computational and Applied Mathematics 273 (2015) 414–427

ELSEVIER

Contents lists available at ScienceDirect

Journal of Computational and Applied Mathematics

journal homepage: www.elsevier.com/locate/cam

An MPI–CUDA library for image processing on HPC architectures

CrossMark

Antonella Galizia *, Daniele D'Agostino, Andrea Clematis

Institute of Applied Mathematics and Information Technologies, National Research Council of Italy, Genoa, Italy

Image Processing with CUDA

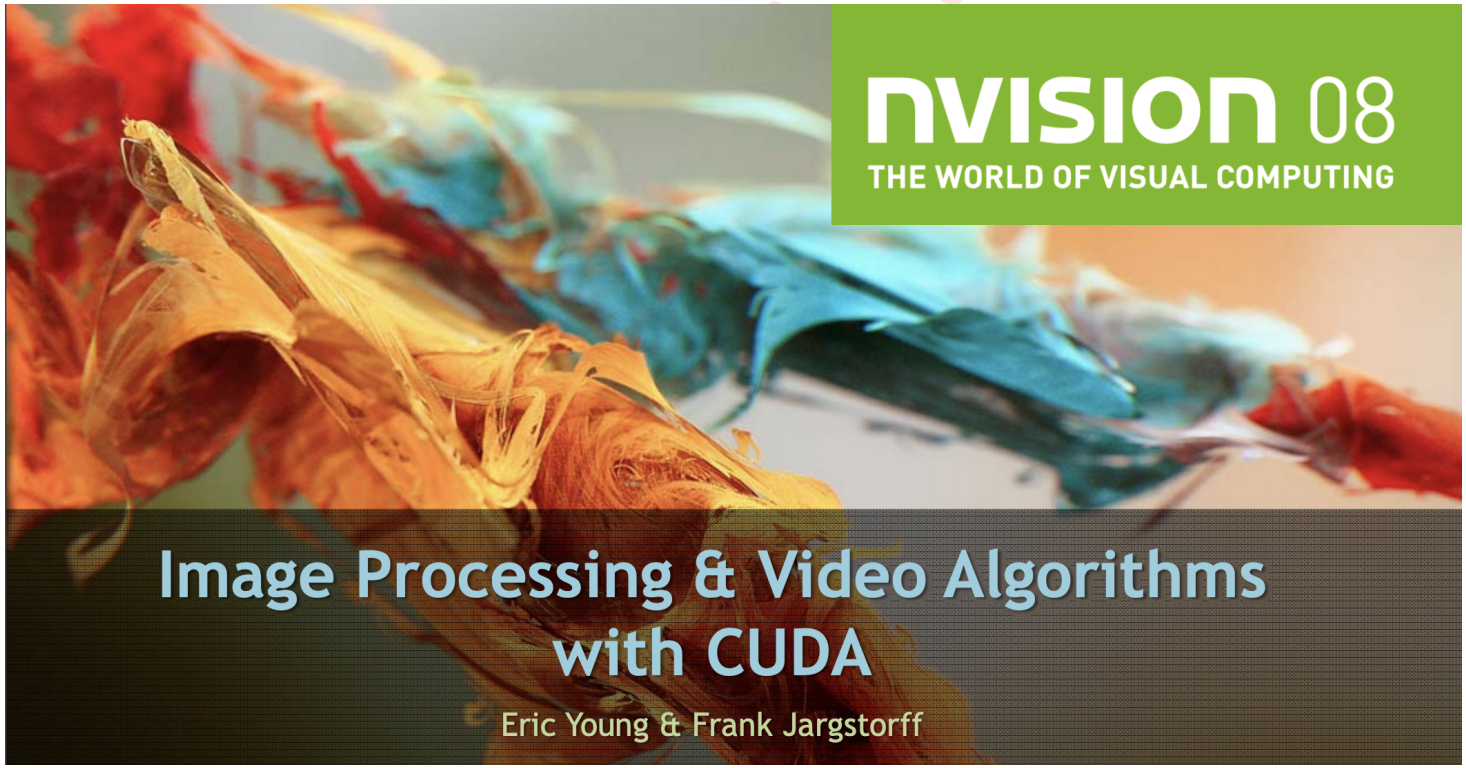
IMAGE PROCESSING WITH CUDA

by

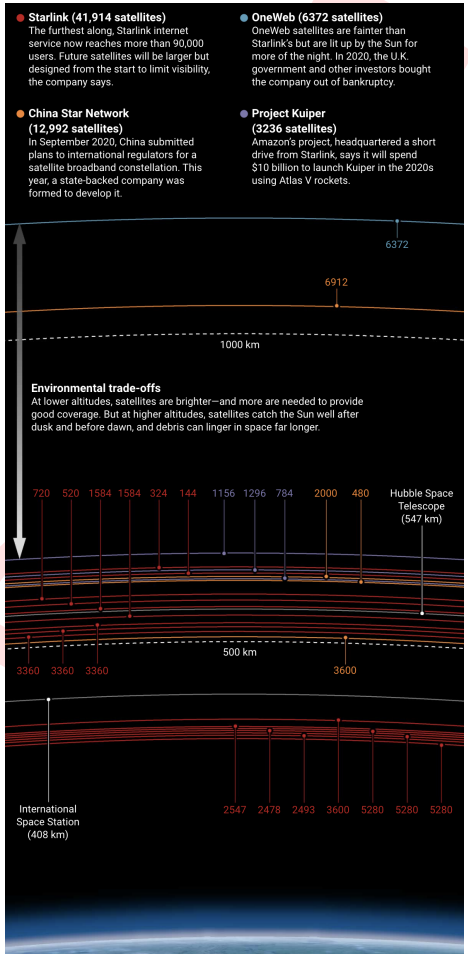
Jia Tse

Bachelor of Science,
University of Nevada, Las Vegas
2006

Image Processing with CUDA



Science – The Fault in Our Stars



What the four largest swarm builders have so far submitted to regulators

Science – The Fault in Our Stars

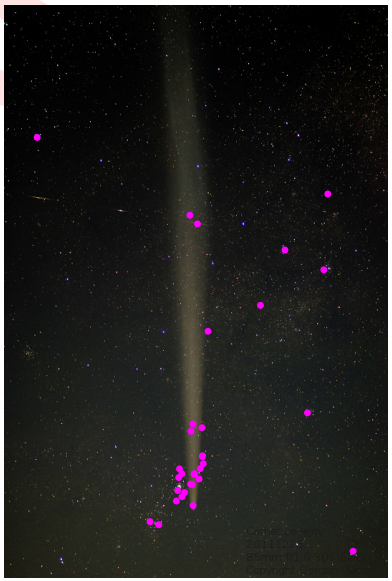
The first flotilla of 60 Starlink satellites was released in May 2019 from a SpaceX rocket.

Mathematica Image Processing

original

edges

key points



backgound out

Not so usefull...

Mathematica Satellite Tools

In[55]:= International Space Station SATELLITE ["Dataset"]

Out[55]=

alternate names	—
altitude	−35° 38' 45.3535"
apogee distance	268.119 mi
longitude of ascending node Ω	226.468°
average altitude	264.89 mi
average orbit velocity	17 129.9 mi/h
azimuth	75° 10' 7.45394"
above the horizon	False
constellation	Camelopardalis
contractor	—
contractor country	—
operator countries	{…22}

First of 63 entries for International Space Station dataset

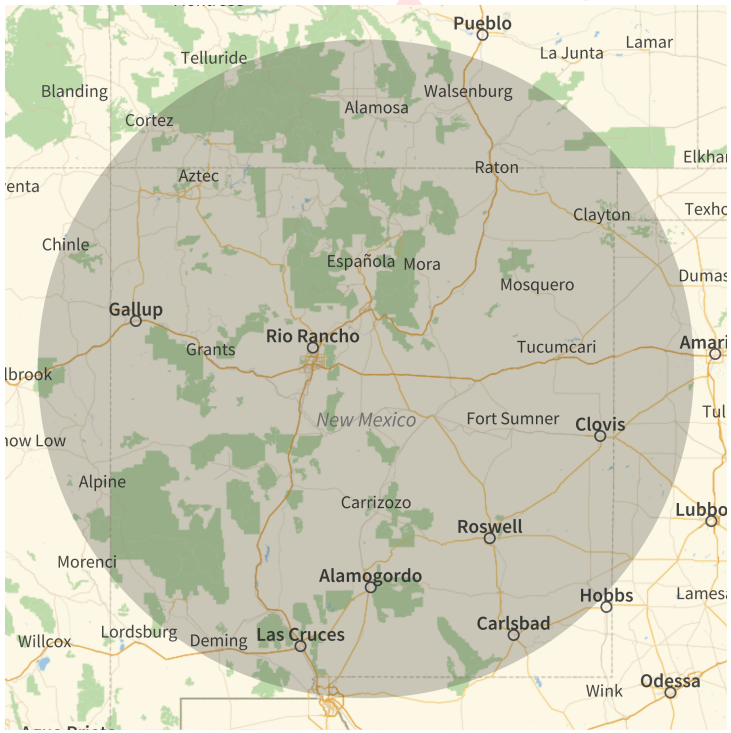
Mathematica Satellite Tools

Groundtracks, International Space Station


```
With[data = EntityValue[ Entity["Satellite", "25544"], "Position", "PositionLine"],
GeoGraphics[Gray, Thickness[.005], Arrowheads[0.05, 0.4, 0.05, 0.13], Arrow @@ data[[2]], Red,
PointSize[.01], Point[data[[1]]], Opacity[.1], Black, GeoVisibleRegion[data[[1]]], GeoCenter ->
data[[1]], GeoRange -> "World"]]]
```

Mathematica GeoVisibleRegion Tools

What's visible from 10,000 m over Albuquerque?




```
GeoGraphics[GeoVisibleRegion[35, -106, 10000]]
```

Mathematica GeoVisibleRegion Tools

What's visible from geostationary orbit over Albuquerque?


```
GeoGraphics[ GeoVisibleRegion[35, -106, Quantity[35786, "Kilometers"]], GeoRange -> "World"]
```

MATLAB Image Processing Toolbox: I

Image Analysis

Extract meaningful information from images, such as finding shapes, counting objects, identifying colors, or measuring object properties.

Documentation | Examples

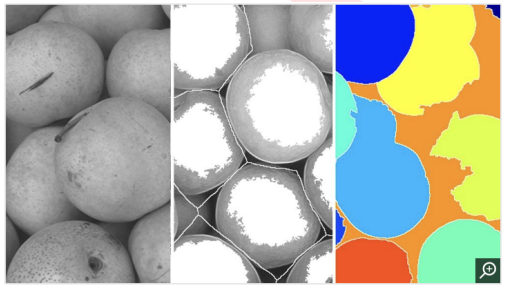
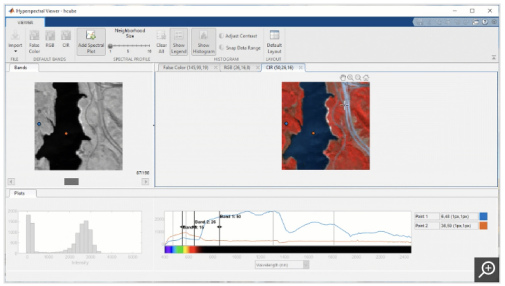


Image Segmentation

Determine region boundaries in an image using different approaches including automatic thresholding, edge-based methods, and morphology-based methods.

Documentation | Examples

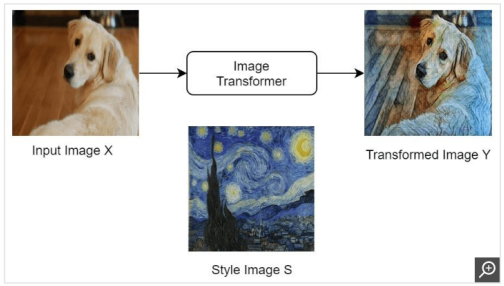


Hyperspectral Image Processing

Read, write, and visualize hyperspectral data in a variety of file formats and process the data using algorithms such as Smile reduction, NDVI, or identifying spectral indices.

Documentation | Examples

MATLAB Image Processing Toolbox: II



Deep Learning in Image Processing

Perform image processing tasks, such as removing image noise and performing image-to-image translation, using deep neural networks.

Documentation | Examples

Image Preprocessing

Enhance contrast, remove noise, and correct blurring using contrast adjustment, morphological operators, and custom or predefined filters.

Documentation | Examples

Acceleration and Deployment

Automatically generate C/C++, CUDA®, and HDL code for prototyping and deploying image processing algorithms to CPUs, GPUs, FPGAs, and ASICs.

Documentation | Examples

Bibliography I

[1] Max Born and Emil Wolf. Principles of optics: electromagnetic theory of propagation, interference and diffraction of light. Elsevier, 2013.

[2] Antonella Galizia, Daniele D'Agostino, and Andrea Clematis. "An MPI–CUDA library for image processing on HPC architectures". In: Journal of Computational and Applied Mathematics 273 (2015), pp. 414–427.

[3] Min Gu. Advanced optical imaging theory. Vol. 75. Springer, 2013.

[4] Jeff Hecht. Optics: light for a new age. Jeff Hecht, 1987.

Bibliography II

[5] M Herzberger. "Direct methods in geometrical optics". In: Transactions of the American Mathematical Society 53.2 (1943), pp. 218–229.

[6] Cyril Richard et al. Siril: An Advanced Tool for Astronomical Image Processing. 2024. arXiv: 2408.03346 [astro-ph.IM]. URL: https://arxiv.org/abs/2408.03346.

[7] Jiasheng Tao. Space Optical Remote Sensing: Fundamentals and System Design. Advances in Optics and Optoelectronics (AOO). Springer, 2003.

New Approaches: Optical, Image Processing and Computing

Daniel Topa
dantopa@gmail.com

University of New Mexico
Department of Mathematics and Statistics

September 17, 2024