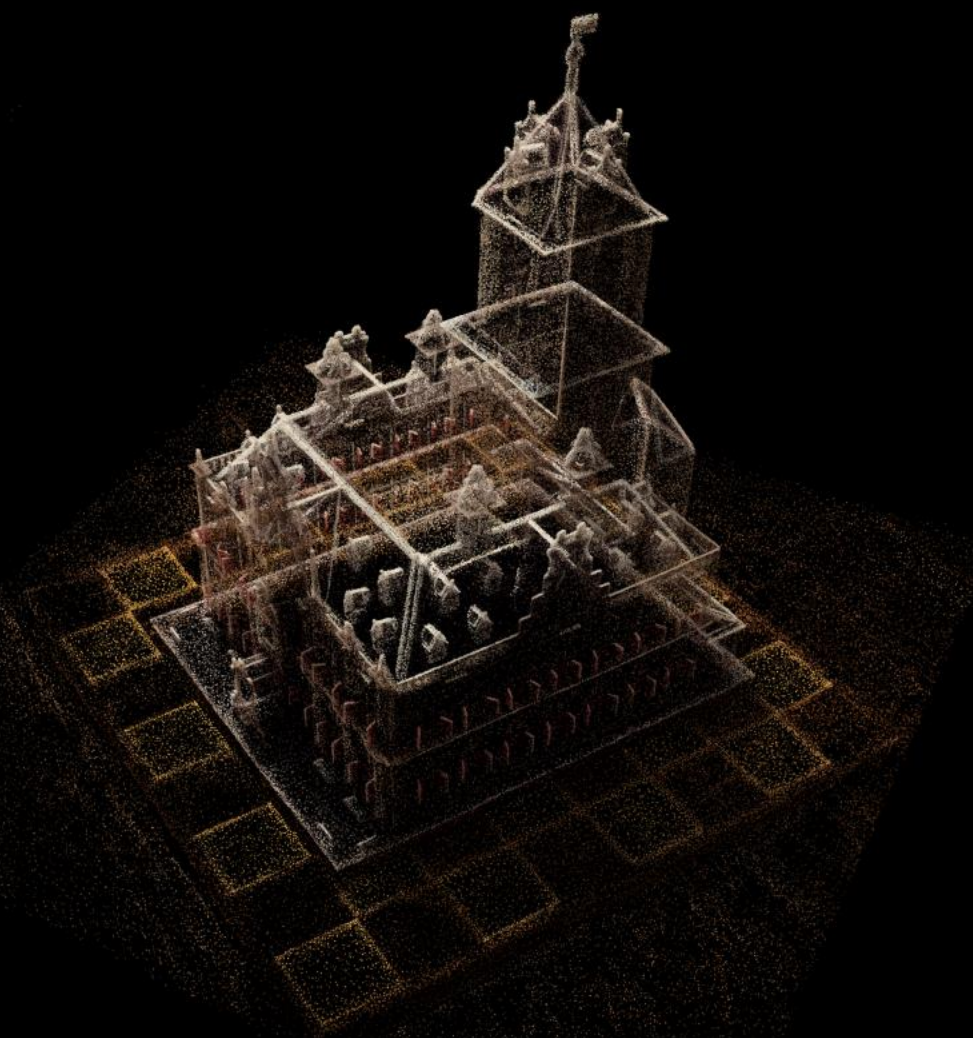


Point Clouds – Gaussian Splatting
“Points essentially become
ellipsoids with learnable size,
orientation, and visual
appearance”

Edward Verbree

e.verbree@tudelft.nl





Rutger Kopland

De Landmeter (1982)

- Het is niet alleen onverschilligheid, in zekere zin is het misschien zelfs wel liefde die hem dwingt, er is geen paradijs zonder rentmeester.
- Hij is gelukkig met het landschap, maar gelukkig met het zoeken, coördinaten wijzen hem zijn onzichtbare plek, zijn utopie is de kaart, niet de wereld.
- Hij wil weten waar hij is, maar zijn troost is te weten dat de plek waar hij is niet anders bestaat dan als zijn eigen formule, hij is een gat in de vorm van
- een man in het landschap. **Met de grenzen die hij trekt, scherper en duidelijker, vervagen het gras en de bomen en alles wat daar leeft, lijdt en sterft.**
- **Het is heel helder om hem heen, alles is waargenomen.**

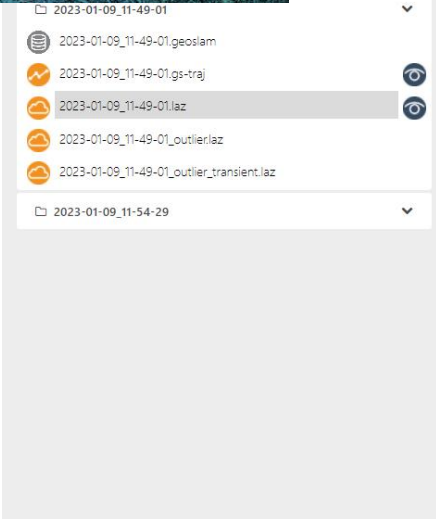
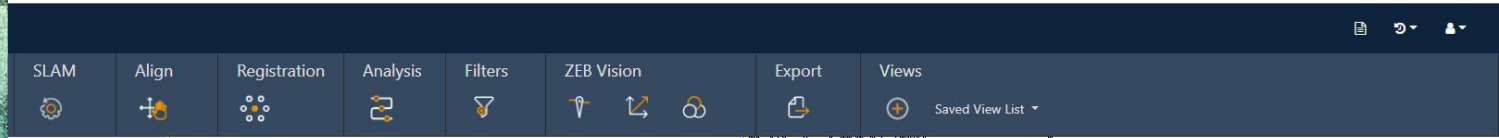
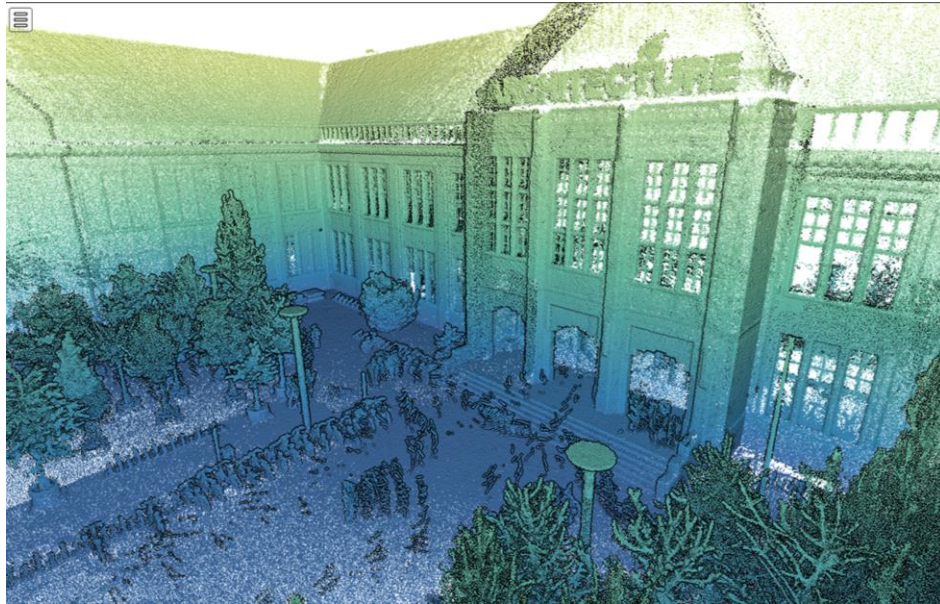
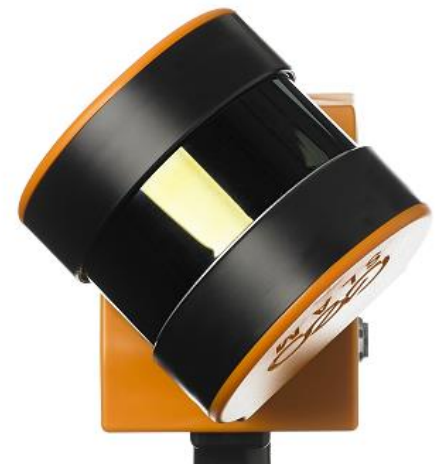
Rutger Kopland

The Surveyor (Translation: James Brockway, 2001)

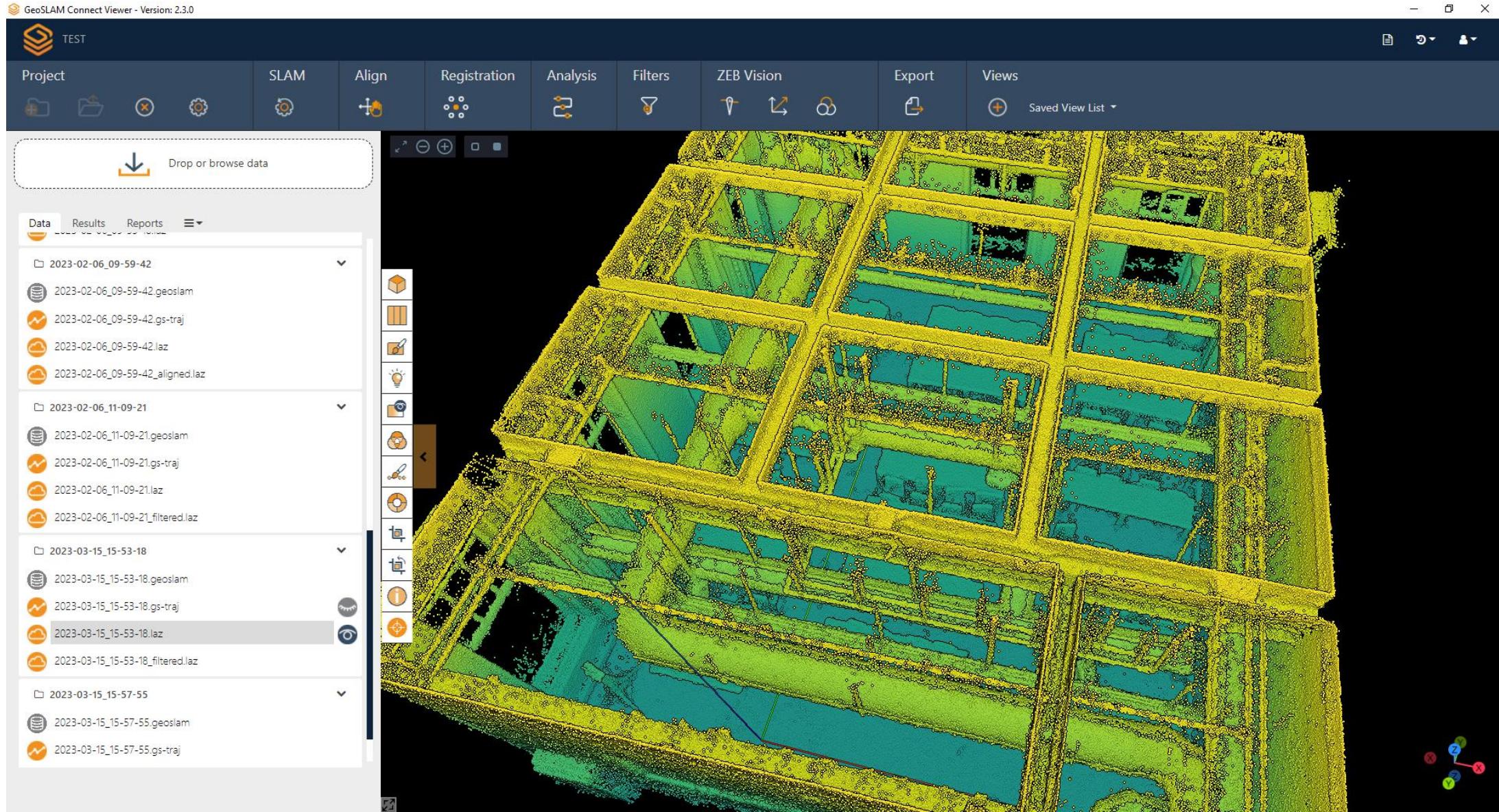
- It isn't mere indifference, in a certain sense it is perhaps even love that drives him on, there's no paradise without its steward.
- He is happy with his landscape, but even happier with searching, co-ordinates point him to his invisible spot, the map, not the world, is his Utopia.
- He wants to know where he is, but it's his consolation to know that the spot where he is standing exists only as his private formula, he is a hole in the shape of
- a man in the landscape. **With the boundaries that he draws, sharper, more distinct, the grass and the trees grow vaguer and everything that lives, declines and dies.**
- **The world around him is perfectly clear, everything has been observed.**

Point Cloud Hardware in Education

GeoSLAM Zeb Horizon



Architecture – Room F – Scanning time 3 minutes

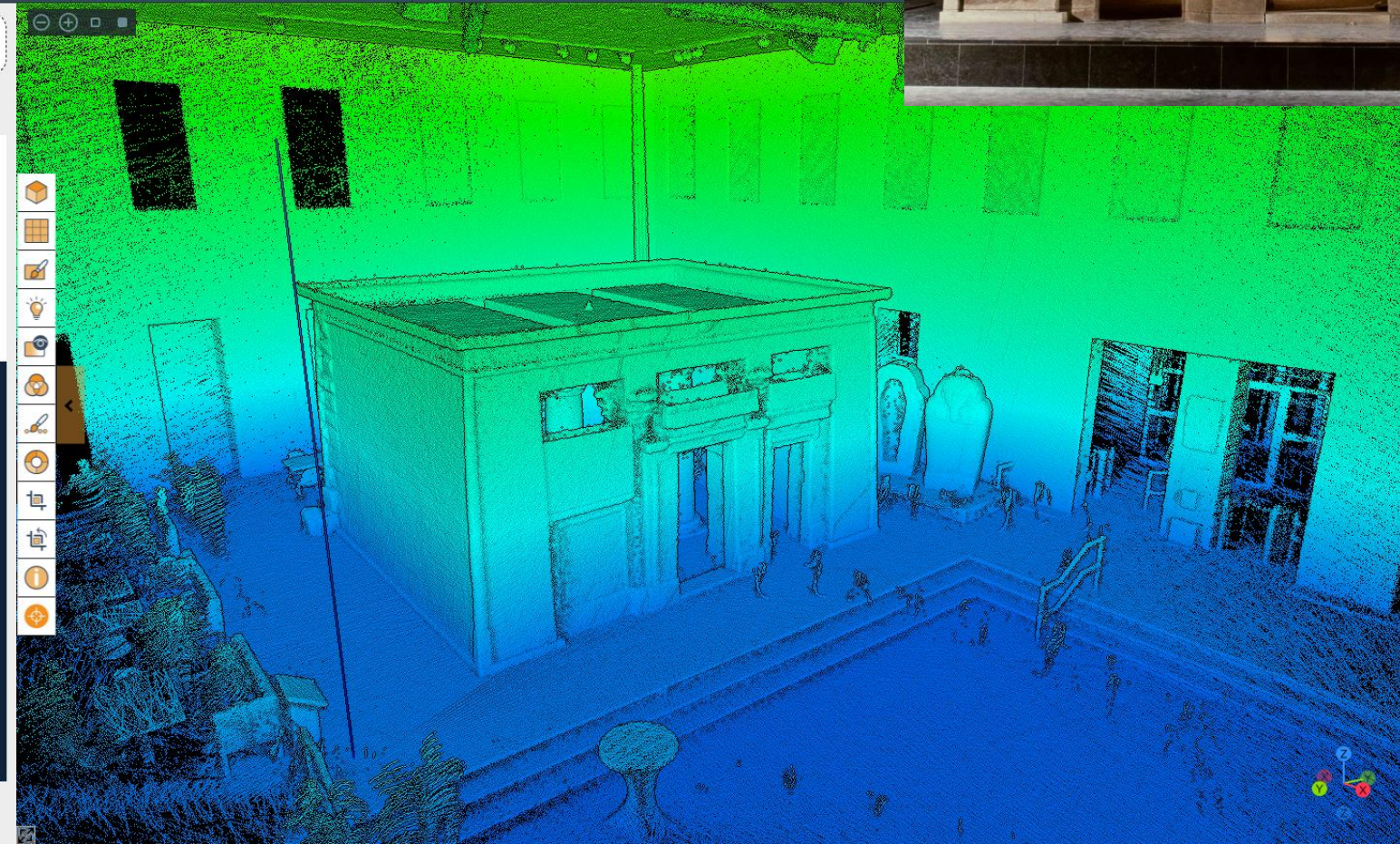
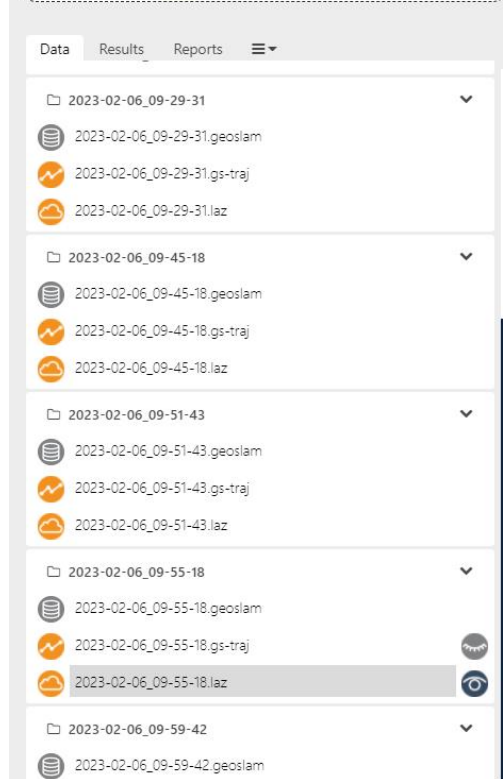
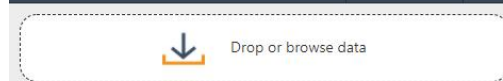
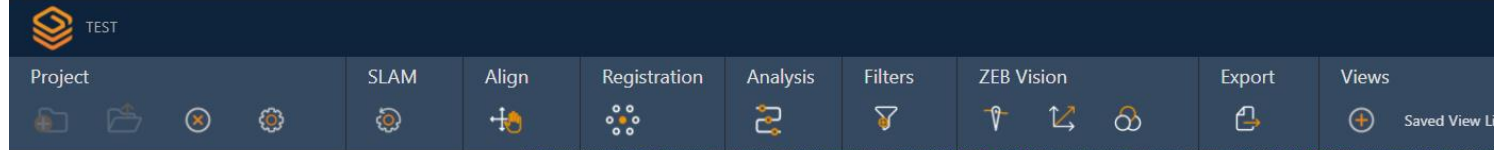


Rijksmuseum van Oudheden, Leiden

Tempel van Taffeh



GeoSLAM Connect Viewer - Version: 2.2.0



ZEB Horizon Vision

FARO Connect Viewer - Version: 2024.2.1

Connect TEST_TUD

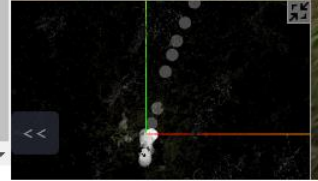


Project ⊗	Reprocess ⌛	Align ↕	Registration 🔄	Analysis 📊	Filters 🔍	Vision Tools 📐	Export 📤	Views + Saved View List ▾
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↓ Drop or browse data

- 2024-05-24_16-22-17
 - 2024-05-24_16-22-17.geoslam
- 2024-05-24_16-22-17-1
 - 2024-05-24_16-22-17.geoslam
 - 2024-05-24_16-22-17.gs-traj
 - 2024-05-24_16-22-17.laz
 - 2024-05-24_16-22-17.gs-vision
 - 2024-05-24_16-22-17_colour.laz
- 2024-02-29_12-46-12-3
 - 2024-02-29_12-46-12.geoslam
 - 2024-02-29_12-46-12.gs-traj
 - 2024-02-29_12-46-12.laz
 - 2024-02-29_12-46-12.gs-vision
 - 2024-02-29_12-46-12_colour.laz
- 2024-05-15_TEST1_TowerCorrect-1
 - 2024-05-15_TEST1_TowerCorrect.geoslam
 - 2024-05-15_TEST1_TowerCorrect.gs-traj
 - 2024-05-15_TEST1_TowerCorrect.laz
 - 2024-05-15_TEST1_TowerCorrect.gs-vision
 - 2024-05-15_TEST1_TowerCorrect_colour.laz

+ Create new sheet



ZEB Horizon Vision

FARO Connect Viewer - Version: 2024.2.1

Connect TEST_TUD

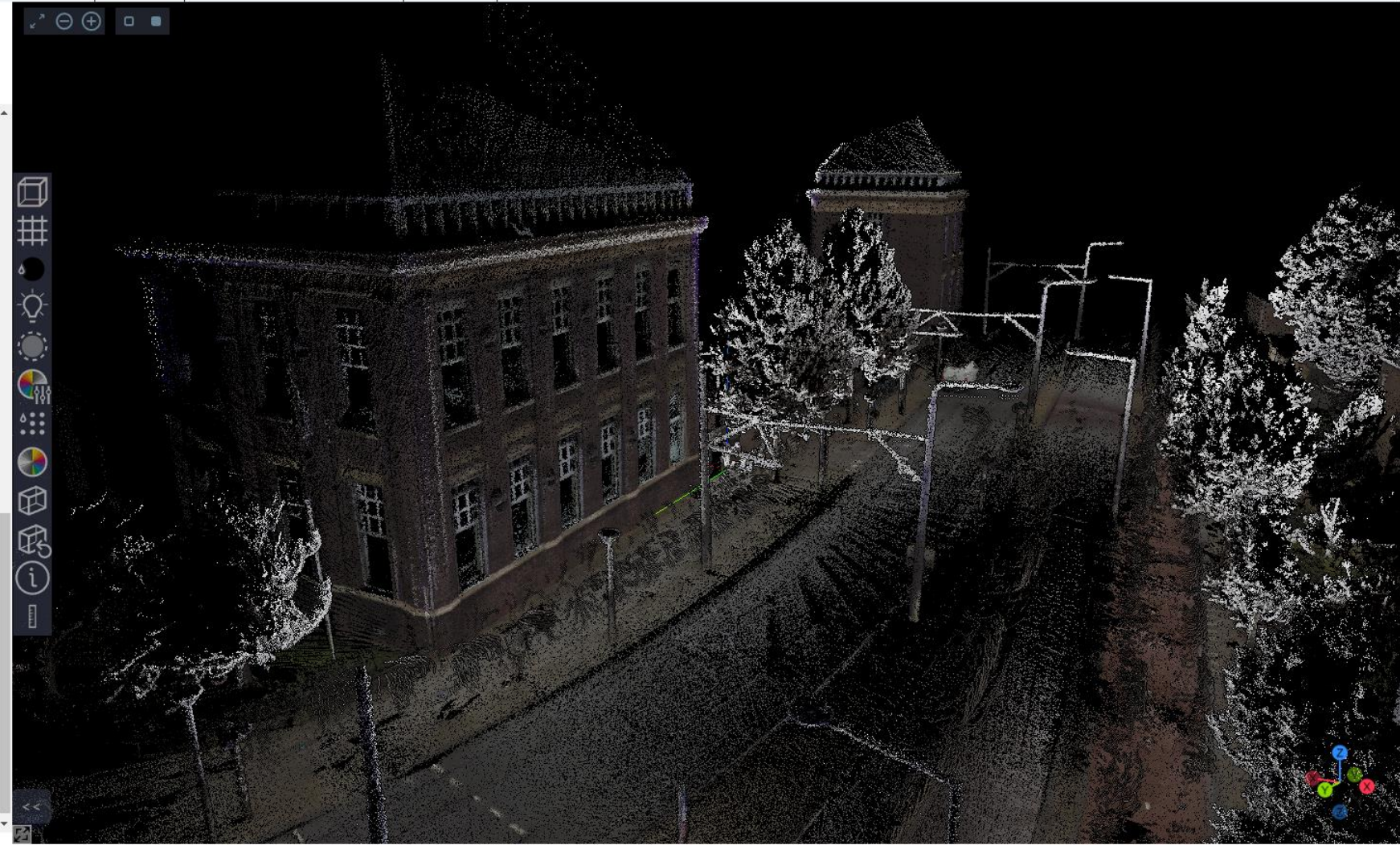


Project ⊗	Reprocess ↻	Align ↕	Registration 🔄	Analysis 📊	Filters 🔍	Vision Tools 📐	Export 📤	Views + Saved View List ▾
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 - 2024-05-24_16-22-17.geoslam
 - 2024-05-24_16-22-17.gs-traj
 - 2024-05-24_16-22-17.laz
 - 2024-05-24_16-22-17.gs-vision
 - 2024-05-24_16-22-17_colour.laz
- 2024-02-29_12-46-12-3
 - 2024-02-29_12-46-12.geoslam
 - 2024-02-29_12-46-12.gs-traj
 - 2024-02-29_12-46-12.laz
 - 2024-02-29_12-46-12.gs-vision
 - 2024-02-29_12-46-12_colour.laz
- 2024-05-15_TEST1_TowerCorrect-1
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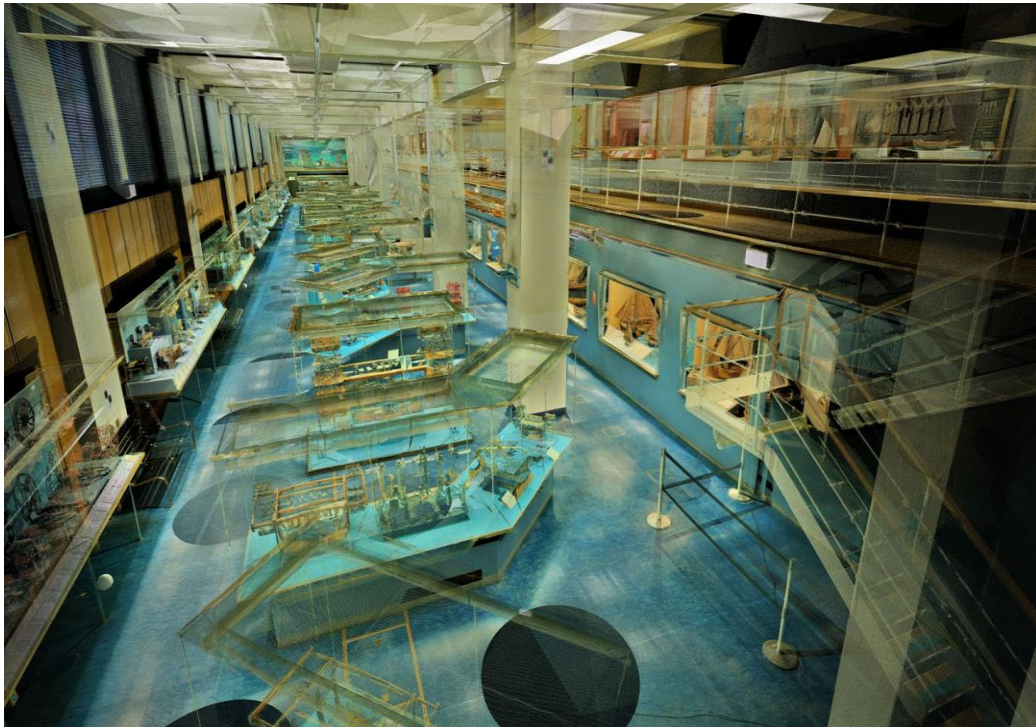
+ Create new sheet



Science Museum - The Shipping Galleries

<http://youtu.be/gDTbFhFZl9I>

- “Every time I walked through, I found something I have not seen before”
- These guys have made a time machine...”
- “Who did ever imagine in 1963 that we could make a virtual shipping gallery out of lasers and computers [...] I can't wait to see how this technology develops”

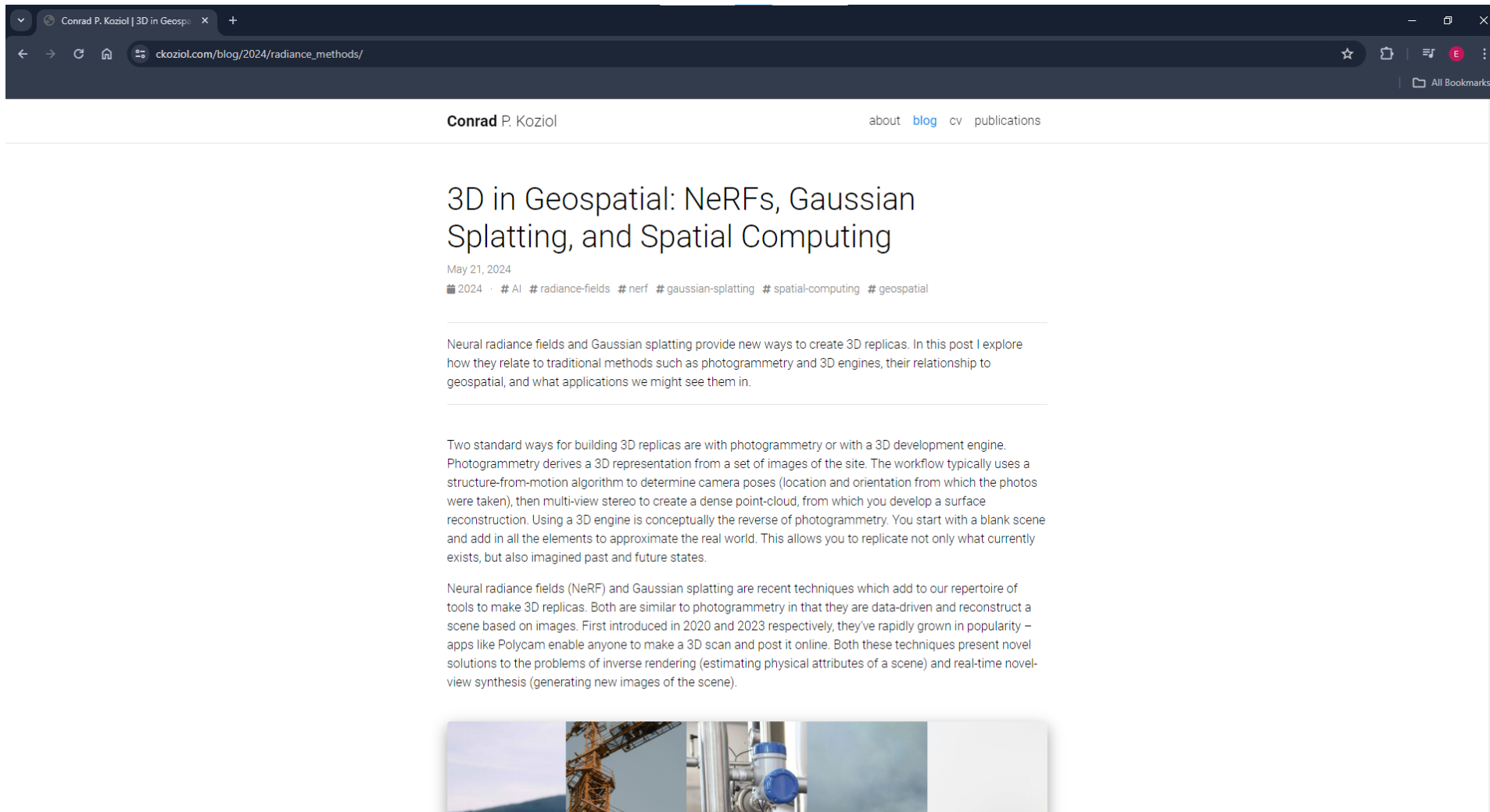


I can't wait to see how this technology develops ...
... Gaussian Splatting

Conrad P. Koziol

NeRFs and Gaussian Splatting

https://ckoziol.com/blog/2024/radiance_methods



The screenshot shows a web browser window with the address bar displaying "ckoziol.com/blog/2024/radiance_methods/". The page header identifies the author as "Conrad P. Koziol" and includes navigation links for "about", "blog", "cv", and "publications". The main content area features the title "3D in Geospatial: NeRFs, Gaussian Splatting, and Spatial Computing" with a date of "May 21, 2024". Below the title are several hashtags: "#2024", "#AI", "#radiance-fields", "#nerf", "#gaussian-splatting", "#spatial-computing", and "#geospatial". The text of the post discusses the relationship between traditional methods like photogrammetry and 3D engines, and newer techniques like NeRF and Gaussian Splatting. It mentions that NeRF and Gaussian Splatting are recent techniques that add to the repertoire of tools for creating 3D replicas. The post also notes that these techniques present novel solutions to problems of inverse rendering and real-time novel-view synthesis.

Conrad P. Koziol about blog cv publications

3D in Geospatial: NeRFs, Gaussian Splatting, and Spatial Computing


May 21, 2024

#2024 · #AI #radiance-fields #nerf #gaussian-splatting #spatial-computing #geospatial

Neural radiance fields and Gaussian splatting provide new ways to create 3D replicas. In this post I explore how they relate to traditional methods such as photogrammetry and 3D engines, their relationship to geospatial, and what applications we might see them in.

Two standard ways for building 3D replicas are with photogrammetry or with a 3D development engine. Photogrammetry derives a 3D representation from a set of images of the site. The workflow typically uses a structure-from-motion algorithm to determine camera poses (location and orientation from which the photos were taken), then multi-view stereo to create a dense point-cloud, from which you develop a surface reconstruction. Using a 3D engine is conceptually the reverse of photogrammetry. You start with a blank scene and add in all the elements to approximate the real world. This allows you to replicate not only what currently exists, but also imagined past and future states.

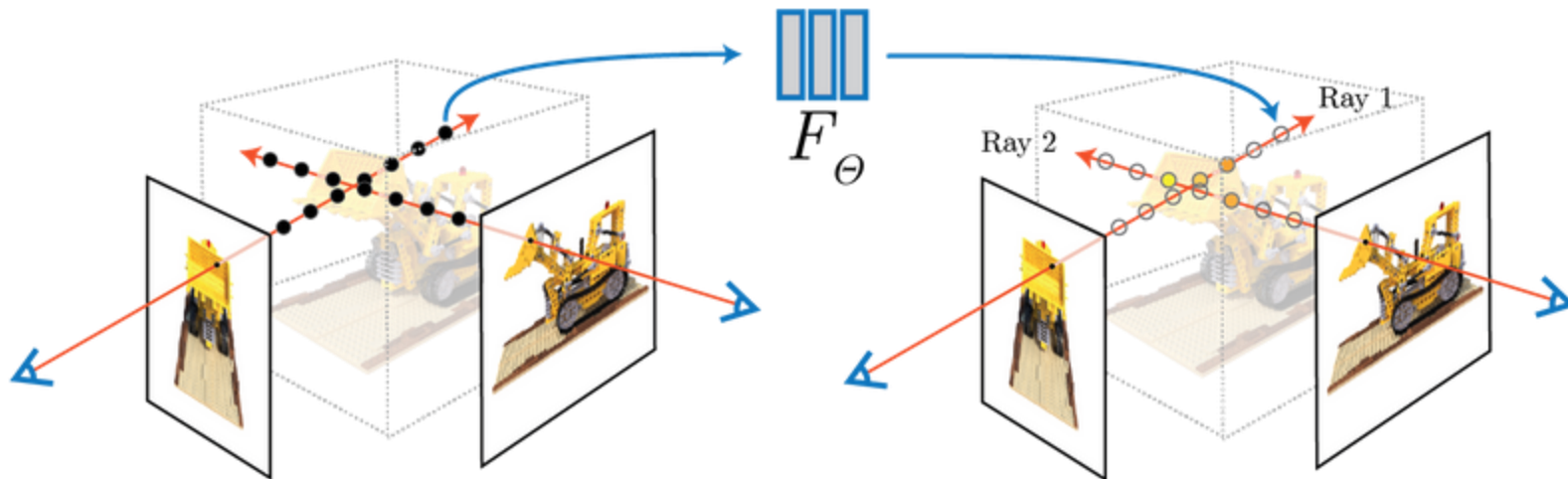
Neural radiance fields (NeRF) and Gaussian splatting are recent techniques which add to our repertoire of tools to make 3D replicas. Both are similar to photogrammetry in that they are data-driven and reconstruct a scene based on images. First introduced in 2020 and 2023 respectively, they've rapidly grown in popularity – apps like Polycam enable anyone to make a 3D scan and post it online. Both these techniques present novel solutions to the problems of inverse rendering (estimating physical attributes of a scene) and real-time novel-view synthesis (generating new images of the scene).



Neural Radiance Fields (NeRFs)

Neural Radiance Fields

NeRFs represent 3D scenes using a neural network, rather than an underlying mesh or point cloud. The inputs to the neural network are spatial location (x, y, z) and viewing direction (θ, ϕ) . The outputs are volume density (σ) and emitted radiance (R, G, B) . To synthesize a view, points sampled along camera rays are input to the neural network and an image is generated from the outputs using volume rendering techniques. The network learns to represent the scene from a set of training images and camera poses, and is optimized using gradient descent. Once trained, new views are synthesized by repeating the process of querying points along the camera ray and rendering the output of the network.



Gaussian Splatting

Gaussian splatting represents 3D scenes similar to point clouds. Points are extended to have a 3D Gaussian distribution in space, opacity (so translucent objects can be represented and for composition of overlapping Gaussians), and spherical harmonics (allowing points to change color as view direction changes). These modifications make Gaussian splats more expressive and better able to reconstruct scenes. Points essentially become ellipsoids with learnable size, orientation, and visual appearance.

An initial (maybe surprising!) observation is that Gaussians can be arranged such that they form an excellent representation of an image. Efficiently going from 3D Gaussian splats to a 2D image for a given camera pose is enabled by a [differentiable renderer](#). The differentiable part is key, because it allows using gradient descent for optimization in tandem with heuristics for adding, splitting, and removing existing Gaussians.



Florant Poux

<https://www.linkedin.com/events/3dgaussiansplatting-livecourse7197161576146108416/theater>

3D Gaussian Splatting: Live Course **LIVE** 145

Phases Overview

3D Gaussian Splatting Desktop Edition

```
graph LR; 1[1. Install PostShot Software] --> 2[2. Download the dataset 1 Images]; 2 --> 3[3. Import the images in PostShot]; 3 --> 4[4. Launch the GS Training]; 4 --> 5[5. Explore the results]; 5 --> 6[6. Generate a Rendering]; 6 --> 7[7. Export the Point Cloud]; 7 --> 8[8. Explore the Point Cloud]; 8 --> 9[9. Import the Dataset 2 Video]; 9 --> 10[10. Gaussian Splatting];
```

3D DATA ACADEMY

Leave

Like, Clap, Heart, Lightbulb, Laugh

Comments:

- #YesWeScan: Hello from Austria!
 Reply
- Josué ADOSSEHOUN: Can we have some resources for beginners?
 Reply
- Mudassar Umar: what is the main advantage of gaussian splatting over sfm
 Reply
- Eric Kant: is this good for buildings, neighborhoods or bigger?
 Reply
- Felix Frey: Improve the ecosystem!
 Eric Kant: Yes, check: <https://dekulitesla.github.io/citygs/>
 Reply
- Eric Kant: Excellent, thanks for link
 Reply

Add a comment...

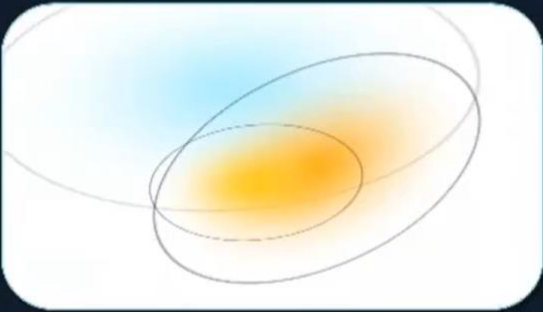
Florant Poux

<https://www.linkedin.com/events/3dgaussiansplatting-livecourse7197161576146108416/theater>

Previously live ATA
ACADEMY

3 Main Concepts

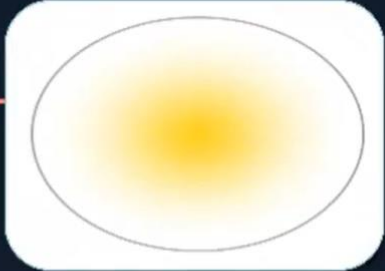
2



Gaussian Splats


Rasterization Technique (Gaussian)

1. Position: where it's located (XYZ)
2. Covariance: how it's stretched/scaled (3x3 matrix)
3. Color: what color it is (RGB)
4. Alpha: how transparent it is (α)



Coupled with S.G.D Training:

1. Rasterize the gaussians to an image using DGR
2. Loss Computation = Difference Rasterized / GT Im
3. Adjust the Gaussian parameters (loss)
4. Apply Densification and Pruning



Florent Poux
3D Data Academy

15:28 1x

Gaussian Splatting

https://projects.markkellogg.org/threejs/demo_gaussian_splats_3d.php

Demo scenes

Garden



Low

High

Truck



Low

High

Stump



Low

High

Bonsai



Low

High

Dynamic scenes



Open

AR/VR



Open

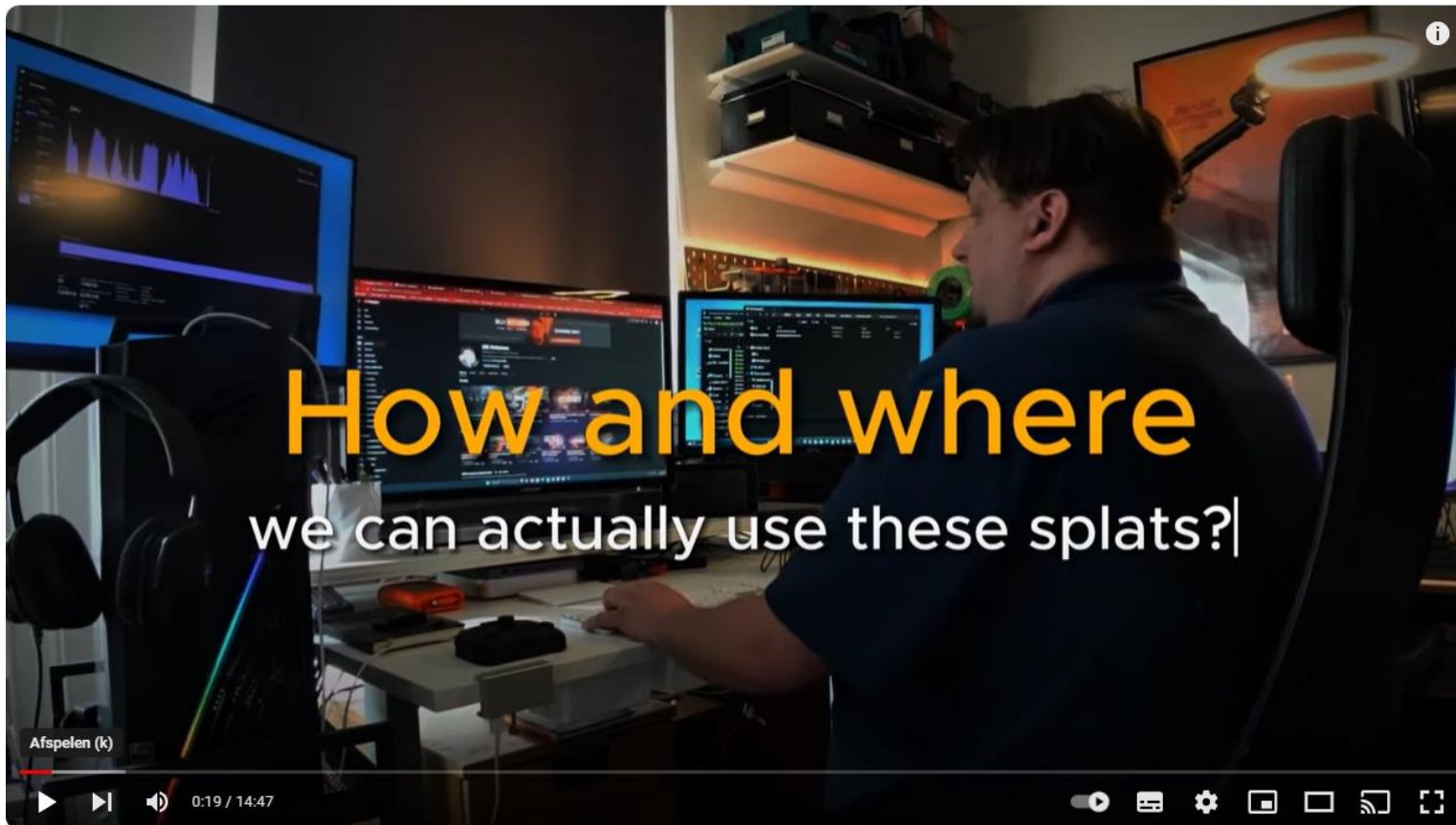
Olli Huttunen – Road map of Gaussian Splatting possibilities

<https://www.youtube.com/watch?v=TB4AjE0w5Xc>

<https://www.youtube.com/watch?v=DQGtimwfpIo>

<https://my.spline.design/untitled-67883b1a43e3efc52206ba2bc4a49956>

<https://www.youtube.com/watch?v=TGZIKPdFZQY>



Road map of Gaussian Splatting possibilities



Olli Huttunen
11,7K abonnees

Geabonneerd ▾

450



Delen



Downloaden



Fragment



A tiny Interactive Gaussian Splatting DEMO



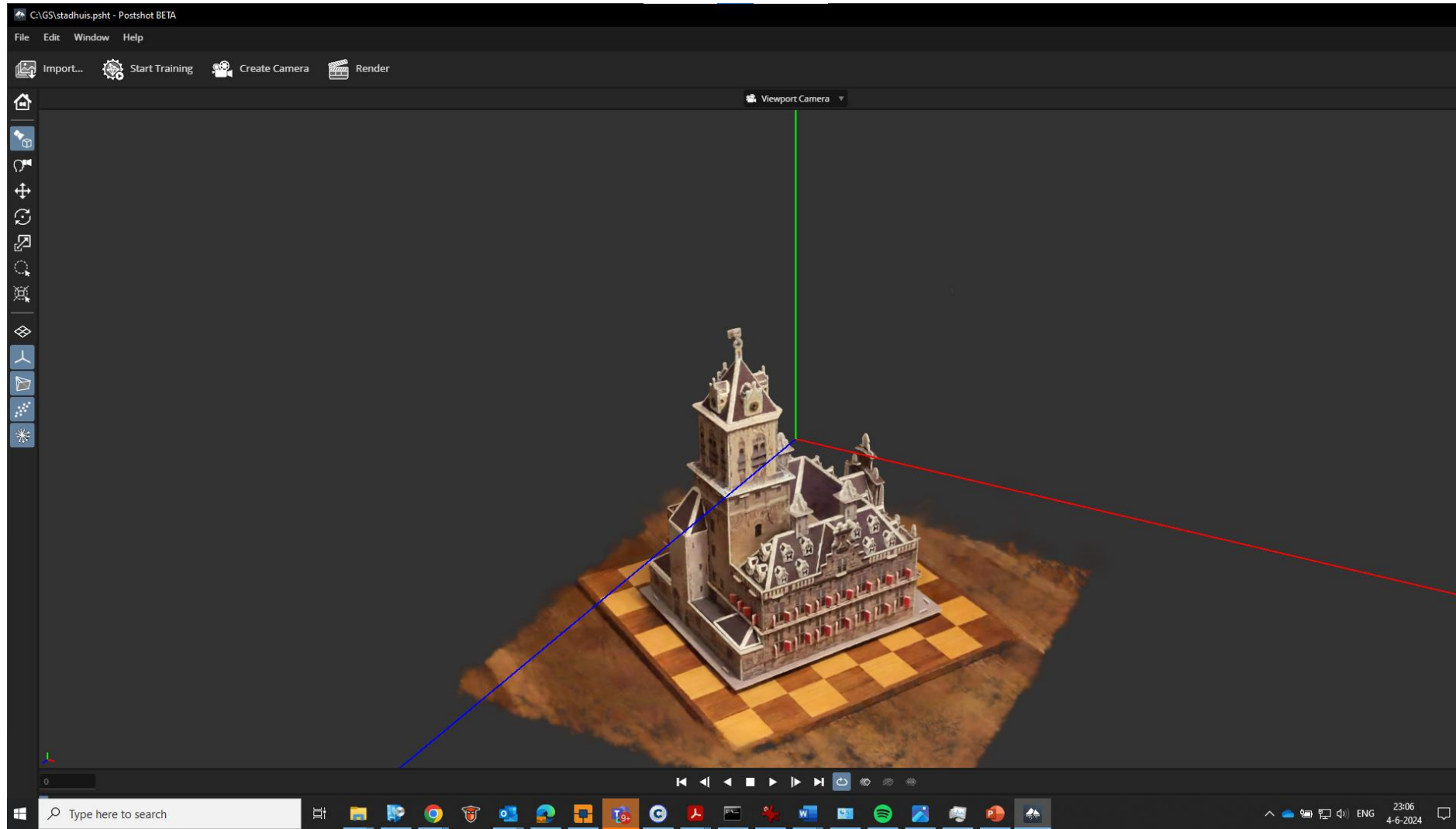


THE

Ghost Wall

Postshot

<https://www.jawset.com>



Radiance Fields - Michael Rubloff

<https://radiancefields.com>

<https://antimatter15.com/splaTV>

The screenshot shows the homepage of the Radiance Fields website. At the top, there is a search bar and a navigation menu with links for Platforms, Job Board, Research, About, Affiliates, Contribute, Contact, Partnerships, and VRAM Calculator. The main content area is divided into sections: PLATFORMS, TRENDING, RESEARCH, and GUEST ARTICLE. The PLATFORMS section features an article titled "Volurama: NeRFs on Mac" with a sub-headline "NeRFs training natively on Mac have arrived with GPU acceleration" and a date of Jun 3, 2024. The TRENDING section includes an article titled "Gastudio" with a sub-headline "Gaussian Splatting methods have continued to pour in over the first three months of the year..." and a date of Apr 8, 2024. The RESEARCH section features two articles: "AtomGS" with a sub-headline "Over the last month, we have repeatedly seen methods that have been exploring Gaussian..." and a date of May 30, 2024; and "Pop Goes the 3DGS Flicker: Stop the Pop" with a sub-headline "If you've interacted with Gaussian Splatting, you might have noticed an issue described as..." and a date of May 26, 2024. The GUEST ARTICLE section includes an article titled "A short 170 year history of Neural Radiance Fields (NeRF), Holograms, and Light Fields" with a sub-headline "Lightfield and hologram capture started with a big theoretical idea 115 years ago and we hav..." and a date of Mar 2, 2023. The website also features social media icons and a "Subscribe" button.

Radiance Fields

Search...


Platforms Job Board Research About Affiliates Contribute Contact Partnerships VRAM Calculator

PLATFORMS

Volurama: NeRFs on Mac

NeRFs training natively on Mac have arrived with GPU acceleration

Michael Rubloff | Jun 3, 2024

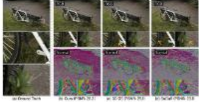


RESEARCH

AtomGS

Over the last month, we have repeatedly seen methods that have been exploring Gaussian...

Michael Rubloff | May 30, 2024

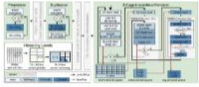


RESEARCH

Pop Goes the 3DGS Flicker: Stop the Pop

If you've interacted with Gaussian Splatting, you might have noticed an issue described as...

Michael Rubloff | May 26, 2024




TRENDING

RESEARCH

Gastudio

Gaussian Splatting methods have continued to pour in over the first three months of the year...

Michael Rubloff | Apr 8, 2024




PLATFORMS

Google CloudNeRF: Zip-NeRF and Camp in the Cloud

It doesn't seem like a lot of people know this, but you can run Camp and Zip-NeRF in the...

Michael Rubloff | May 8, 2024




GUEST ARTICLE

A short 170 year history of Neural Radiance Fields (NeRF), Holograms, and Light Fields

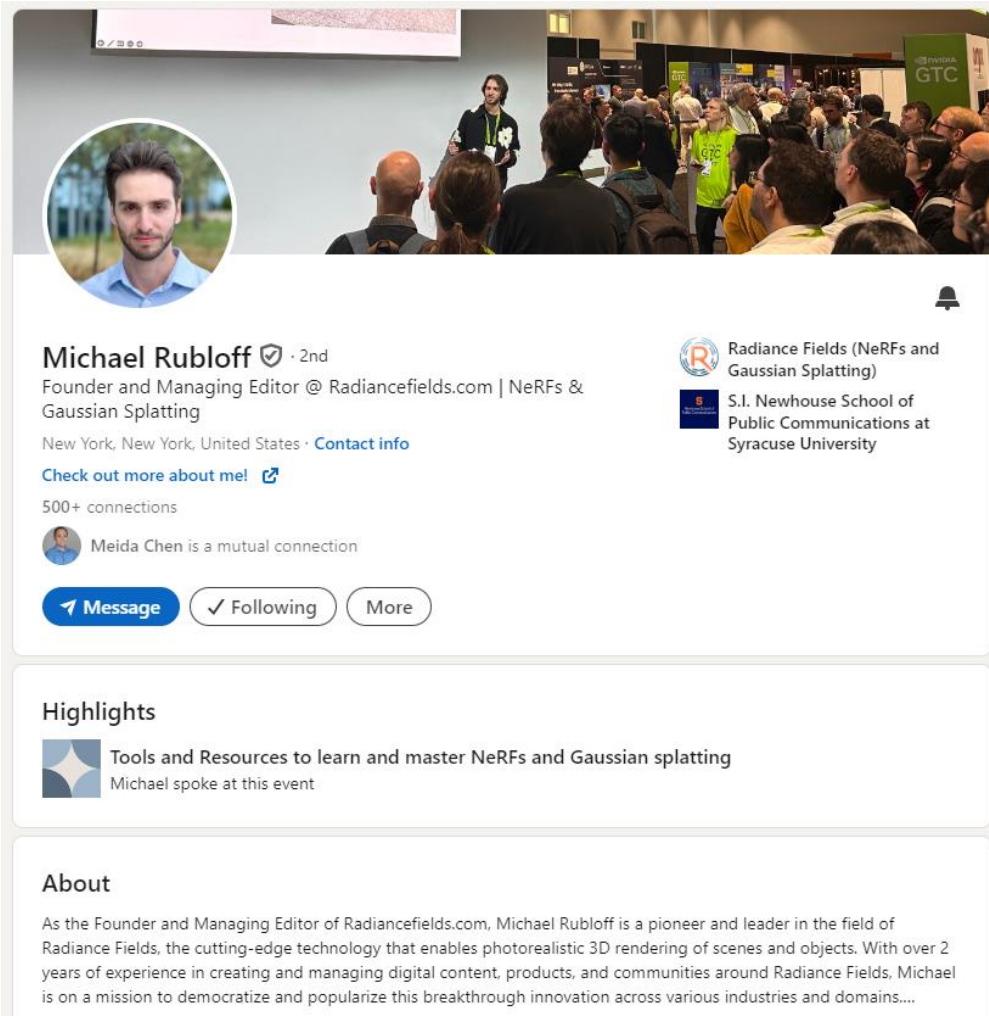
Lightfield and hologram capture started with a big theoretical idea 115 years ago and we hav...

Katrin Schmid | Mar 2, 2023



Radiance Fields - Michael Rubloff

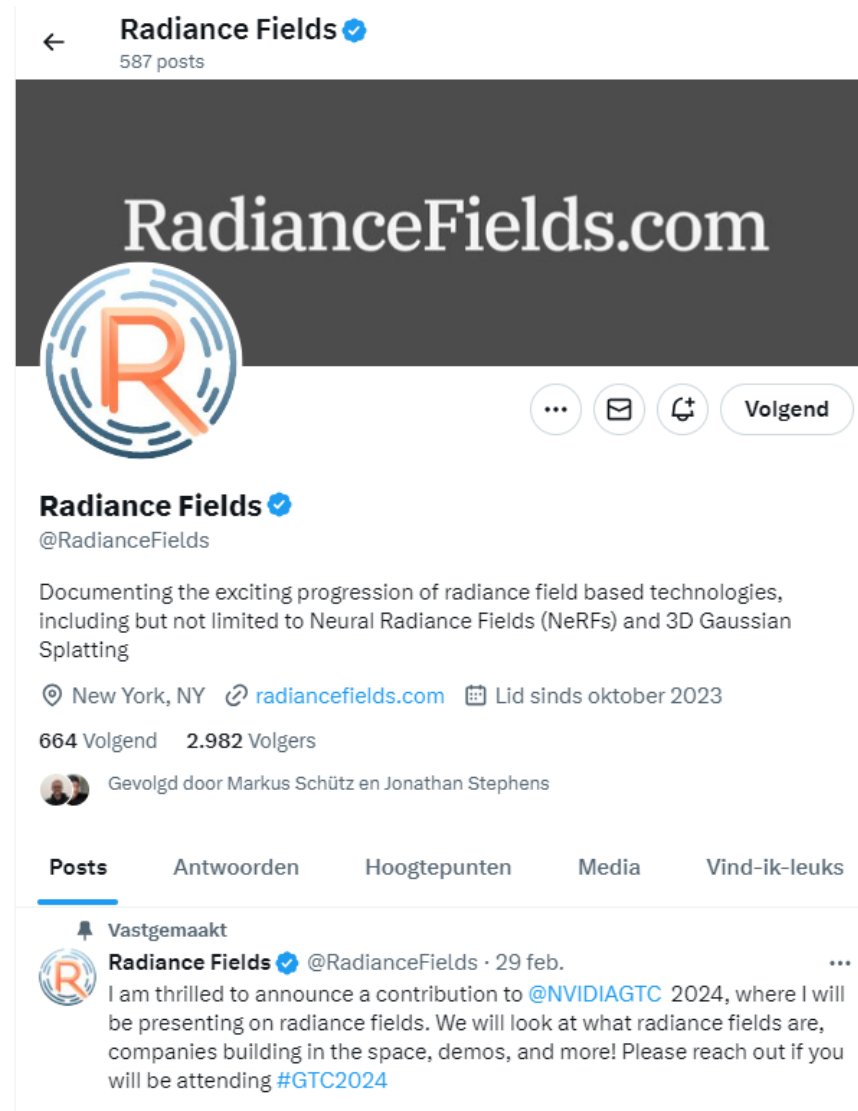
LinkedIn / Twitter(X)



Michael Rubloff · 2nd
Founder and Managing Editor @ Radiancefields.com | NeRFs & Gaussian Splatting
New York, New York, United States · [Contact info](#)
[Check out more about me!](#)
500+ connections
Meida Chen is a mutual connection
[Message](#) [Following](#) [More](#)

Highlights
Tools and Resources to learn and master NeRFs and Gaussian splatting
Michael spoke at this event

About
As the Founder and Managing Editor of Radiancefields.com, Michael Rubloff is a pioneer and leader in the field of Radiance Fields, the cutting-edge technology that enables photorealistic 3D rendering of scenes and objects. With over 2 years of experience in creating and managing digital content, products, and communities around Radiance Fields, Michael is on a mission to democratize and popularize this breakthrough innovation across various industries and domains....



Radiance Fields ✓
587 posts

RadianceFields.com

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Documenting the exciting progression of radiance field based technologies, including but not limited to Neural Radiance Fields (NeRFs) and 3D Gaussian Splatting

New York, NY · [radiancefields.com](#) · Lid sinds oktober 2023

664 Volgend 2.982 Volgers
Gevolgd door Markus Schütz en Jonathan Stephens

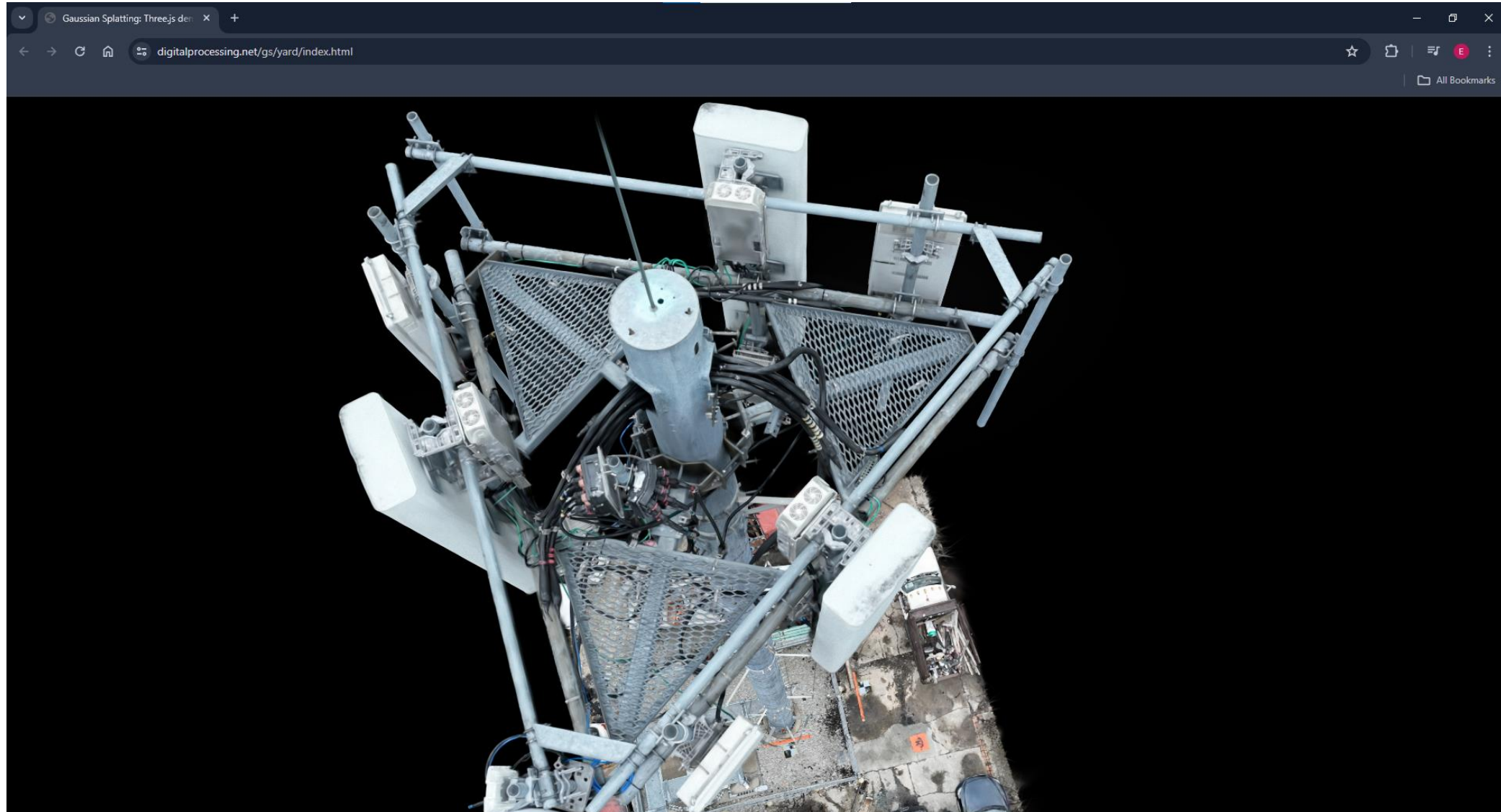
Posts Antwoorden Hoogtepunten Media Vind-ik-leuks

Vastgemaakt
Radiance Fields ✓ @RadianceFields · 29 feb.
I am thrilled to announce a contribution to @NVIDIAGTC 2024, where I will be presenting on radiance fields. We will look at what radiance fields are, companies building in the space, demos, and more! Please reach out if you will be attending #GTC2024



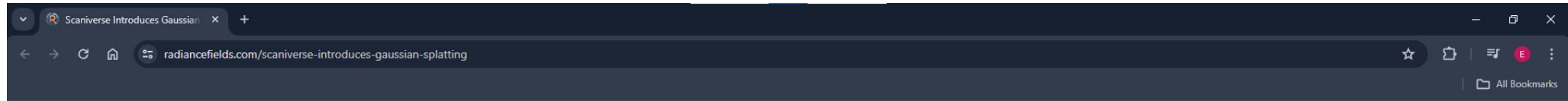
Striking demo

<https://digitalprocessing.net/gs/yard/index.html>



Scaniverse – Capture Life in 3D

<http://scaniverse.com>



Search...

Radiance Fields




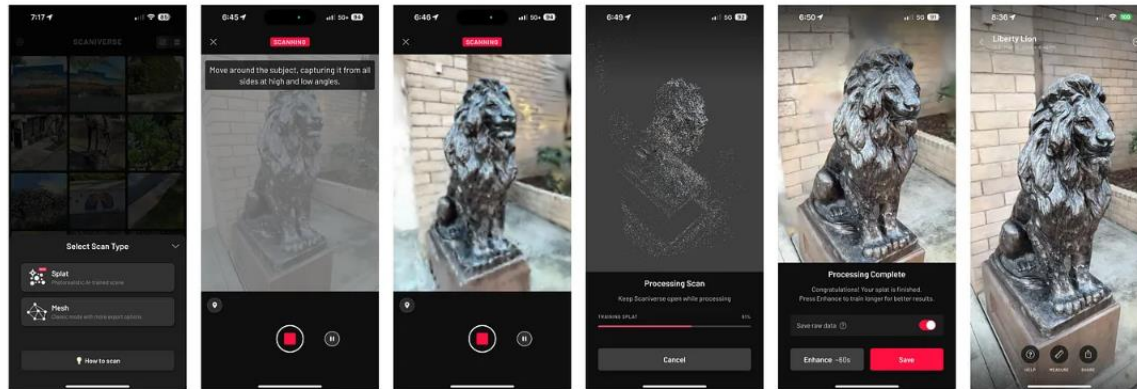
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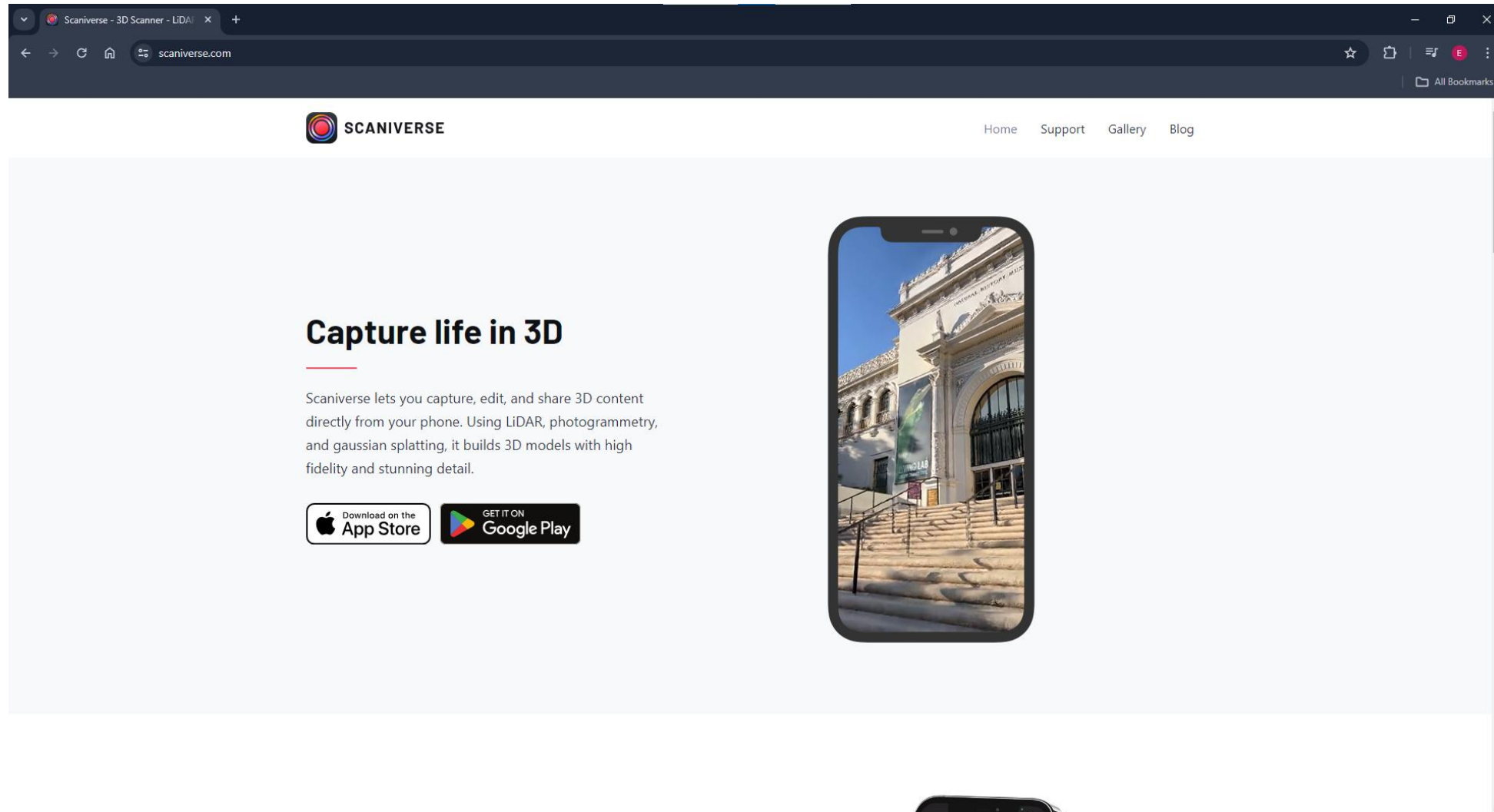
PLATFORMS

Scaniverse Introduces Gaussian Splatting

 Michael Rubloff | Mar 22, 2024



Capture Life in 3D



The image is a screenshot of a web browser displaying the Scaniverse website. The browser's address bar shows the URL 'scaniverse.com'. The website's header includes the Scaniverse logo and navigation links for 'Home', 'Support', 'Gallery', and 'Blog'. The main content area features a large heading 'Capture life in 3D' with a red underline. Below the heading is a paragraph of text describing the app's capabilities. To the right of the text is a vertical smartphone image showing a 3D scan of a building's entrance. At the bottom left, there are two buttons for downloading the app: 'Download on the App Store' and 'GET IT ON Google Play'.

SCANIVERSE

Home Support Gallery Blog

Capture life in 3D

Scaniverse lets you capture, edit, and share 3D content directly from your phone. Using LiDAR, photogrammetry, and gaussian splatting, it builds 3D models with high fidelity and stunning detail.

Download on the App Store

GET IT ON Google Play

Zeb Horizon Vision - To do ...

<https://arxiv.org/pdf/2402.13255>

<https://github.com/Lee-JaeWon/2024-Arxiv-Paper-List-Gaussian-Splatting>

How NeRFs and 3D Gaussian Splatting are Reshaping SLAM: a Survey

Fabio Tosi¹ Youmin Zhang^{1,2} Ziren Gong¹ Erik Sandström³
Stefano Mattocchia¹ Martin R. Oswald^{3,4} Matteo Poggi¹

¹University of Bologna, Italy ²Rock Universe, China ³ETH Zurich, Switzerland ⁴University of Amsterdam, Netherlands

Abstract—Over the past two decades, research in the field of Simultaneous Localization and Mapping (SLAM) has undergone a significant evolution, highlighting its critical role in enabling autonomous exploration of unknown environments. This evolution ranges from hand-crafted methods, through the era of deep learning, to more recent developments focused on Neural Radiance Fields (NeRFs) and 3D Gaussian Splatting (3DGS) representations. Recognizing the growing body of research and the absence of a comprehensive survey on the topic, this paper aims to provide the first comprehensive overview of SLAM progress through the lens of the latest advancements in radiance fields. It sheds light on the background, evolutionary path, inherent strengths and limitations, and serves as a fundamental reference to highlight the dynamic progress and specific challenges.

Index Terms—Simultaneous Localization and Mapping, SLAM, Deep Learning, Neural Radiance Field, NeRF, 3D Gaussian Splatting

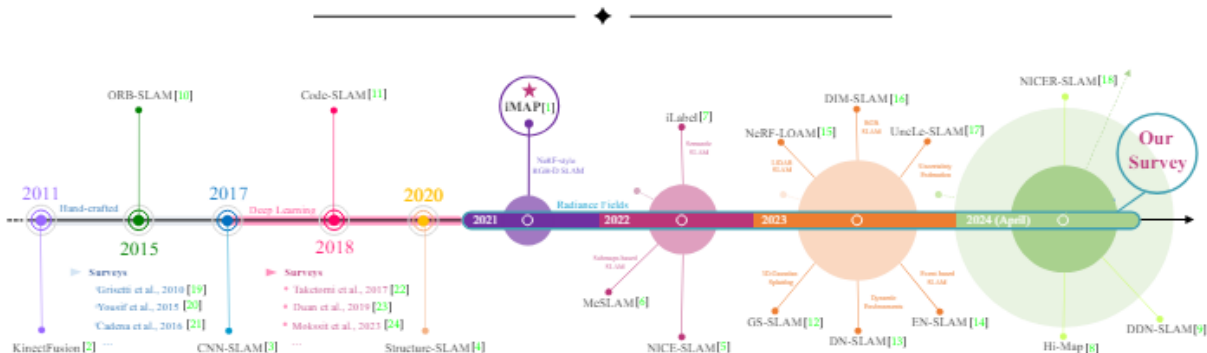


Fig. 1: **Timeline SLAM Evolution.** This timeline begins by illustrating the transition from hand-crafted to deep learning techniques, featuring key surveys from both eras. In 2021, a pivotal shift focuses on radiance-field-based SLAM systems, marked by iMap [1]. The circles on the right side of the figure represent key papers for each year, with size indicating publication volume. The outer circle for 2024 signals a projected surge, highlighting the growing interest in NeRF and 3DGS-inspired SLAM.