Gaussian Splats
Ready for Standardization?

Metaverse
STANDARDS FORUM™

Wednesday, January 22

Intro

- Co-Host: **Patrick Cozzi**, Chief Platform Officer, Bentley Systems and Co-Chair 3D Asset Interoperability WG at the Forum
- Co-Host: **Alexey Medvedev**, AR Tech Lead at Meta and Chair of Khronos' 3D Formats Working Group

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Forum Mission – *Pragmatic* Metaverse Interoperability

2,600 Forum members *assist*ing standards organizations in their mission to enable metaverse interoperability - open to all!

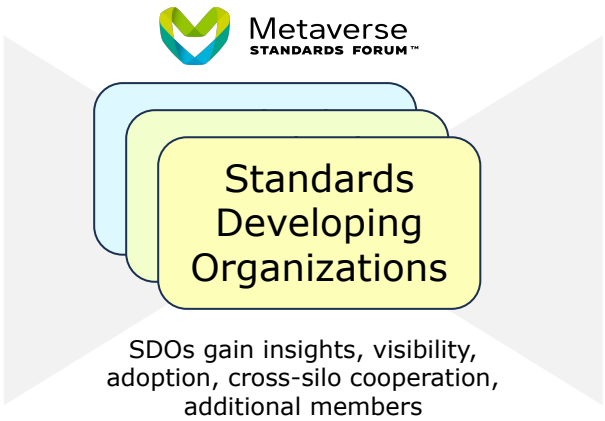
Pre-standardization

Identification of standardization gaps

Discovery of opportunities for standards organizations to leverage or align each others work

Create broad consensus on use cases and requirements

Generating reviews and feedback for draft specifications



Post-standardization

Interoperability testing and testbeds

Development of conversion and layering tools

Publication of educational materials, reports, best practices & guidelines etc.

Bottom-up, pre- and post-standardization activities help address urgent interoperability 'pain points' creating a wavefront of short-term business opportunities on the road to an open, standards-based metaverse

Join the Forum!
https://metaverse-standards.org/

Standardization: Timing is Everything

DON'T do R&D by standards committee!

Optimal standardization window

Fragmentation through multiple proprietary technologies can be hard to reconcile

A technology is still evolving and use cases are emerging - premature standardization may stifle innovation

A technology is becoming proven and there is growing consensus on the fragmentation pain of NOT having a standard

Technology has become widely used before standardization

Presenting Today

The New York Times

NIANTIC

Meta

NVIDIA

PLAYCANVAS

Microsoft

ARRIVAL.SPACE

WALDEK TECHNOLOGIES

Bentley

CESIUM

HEXAGON

esri

EARTHBRAIN

JDULTRA

Agenda

8:05 - Foundations	8:39 - Momentum
1. Michael Rubloff, Founder and Managing Editor, Radiance Fields 2. Aras Pranckevičius, Programmer 3. A.J. Chavar, Creative Strategist & Nick Bartzokas, Senior Software Engineer – R&D The New York Times Q&A	1. Nicholas Butko, Senior Director, Engineering, Niantic, Inc. 2. Nemanja Bartolovic, Software Engineer & Ashish Singh, Product Management, Cloud-AI, RL-Meta 3. Nicolas Moenne-Loccoz, Principal Research Engineer, ADLR, NVIDIA Q&A
9:15 - Web	**9:58 - Geospatial & Digital Twins – 2 Parts**
1. Will Eastcott, CEO & Co-founder, PlayCanvas 2. Cedric Guillemet, Senior Software Development Engineer, Microsoft 3. Thomas Richter-Trummer, Co-Founder & CTO, Arrival.Space 4. Yoshiharu Sato, Founder & CTO, Waldek Technologies Q&A	1. Renaud Keriven, Distinguished Engineer, Bentley Systems 2. Jason Sobotka, Software Engineer, Cesium 3. Ladislav Horký, CTO at Melown Technologies, Hexagon Q&A 1. Konrad Wenzel, Director, Stuttgart R&D Center and Jean-Philippe Pons, Sr. Principal Software Development Engineer, Esri 2. Takayuki Murayama, Senior Director & Talha Khalid, Global Development Manager, EARTHBRAIN 3. Emeric Beaufays, Geospatial and 3D Specialist, Founder & Software Engineer, JDULTRA Q&A
11:00-11:30 - Global Q&A and Wrap Up	

Q&A Guide

- This meeting is being recorded and will be shared afterward
- Please name yourself ‘Your Company: Your Name’
  - Mouse over your name in the Zoom participant list, and select ‘More / Rename’
- Use Discord during and after presentations for Q&A
  - https://discord.gg/WknzaE86
  - This will persist after the town hall

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How to Participate

- **Speaker Questions**

  During the presentations, please submit your questions to the speakers by using the Zoom Q&A feature, not the chat button. At the end of each section, our moderator will put as many questions as possible to the speaker.
  We also encourage you to use Discord, which will help us continue the conversation →https://discord.com/invite/rcNRRryf
- **Recording**

  We are recording this meeting and will be sharing it via the event page on the Metaverse Standards Forum website. A direct link will be emailed post-event.
- **Survey**

  To help us design future MSF events, we would appreciate it if you could complete the short survey form that will pop up at the end of the webinar. The survey link will also be sent out in our follow up email.

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Town Hall Presenter Notes (will be deleted EOD)

- Audience Participation
  - Zoom Q&A will be active
  - Discord will also be used and allow us to continue the conversation.
- Overview of agenda and timings
  - Presentation order (7 min each)
  - Speakers will each introduce themselves
- Join the meeting up to 1 hour early
  - You must register for this meeting and use that join link on Wednesday.
  - Make sure you are on the line 15 min before start time.
  - Please keep your screenshare up the entire time (until someone takes it from you)
- Final Notes
  - Be sure to update Zoom!
  - Final presentations should be uploaded/copied into this slide deck by EOD Monday, January 20th OR ASAP
    - Copy the speaker graphic on a slide before your presentation.

Foundations

- **Michael Rubloff**, Founder and Managing Editor, RadianceFields.com
- **Aras Pranckevičius**, Programmer
- **A.J. Chavar**, Creative Strategist & **Nick Bartzokas**, Senior Software Engineer – R&D The New York Times

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Gaussian Splatting Town Hall

Michael Rubloff
radiancefields.com

The Evolution of Imaging

For nearly 190 years, imaging has primarily been created, shared, and experienced in 2D.

"We live in a 3D world, but the content that we enjoy is flat."

– Tim Cook

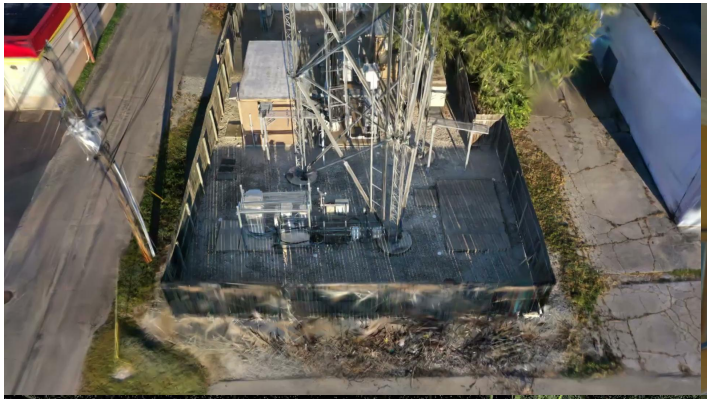
The Evolution of Imaging

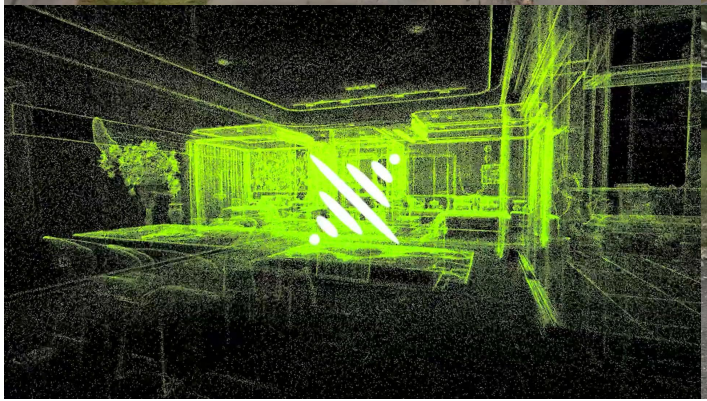
For nearly 190 years, imaging has primarily been created, shared, and experienced in 2D.

We stand on the precipice of transitioning imaging into 3D.

Jamie Portolese

Michael Rubloff





XGRIDS

Antoine Guédon

3D Gaussian Splatting (3DGS)

Gaussian Splatting has rapidly grown in capability since its publication.

Published in late April 2023
Co-first authors Bernhard Kerbl & Georgios Kopanas

SIGGRAPH 2023 Best Paper Award Winner

Able to reconstruct View Dependent Effects
Accurate reflections and complex lighting

Significant Advancements
Reconstruction time, fidelity, compression, tooling, and VRAM requirements have all exponentially improved

The Rise of Radiance Fields

Two current popular Radiance Field methods are Gaussian Splatting and NeRFs.

NeRFs and Gaussians are not the only Radiance Field methods

Plenoxels: Radiance Fields without Neural Networks
TRIPS: Trilinear Point Splatting
Quadrature Fields: Volumetric Rendering with Baked Quadrature Fields
SMERF: Streamable Memory Efficient Radiance Fields
INPC: Implicit Neural Point Clouds
3D Gaussian Ray Tracing 3DGRT (Not Gaussian Splatting)
EVER: Exact Volumetric Ellipsoid Rendering
3D Convex Splatting: Radiance Field Rendering with 3D Smooth Convexes

3DGS Project Page

Radiance Fields will influence all industries that currently use 2D images or video.

Advantages of Gaussian Splatting

Gaussian Splatting is the first bridge to industry adoption of Radiance Field methods.

Renders Faster Than Real-Time
Achieves high frame rates well above real-time

Capture With Any Camera
Reconstruct purely from 2D images
Revisit majority of existing Photogrammetry datasets

Lightweight & Computationally Inexpensive
Trains on consumer grade GPUs and mobile phones

Fast to Train
Training time as short as 2 minutes
Will be instantaneous in the future

Gradeterna

Advantages of Gaussian Splatting

Gaussian Splatting is the first bridge to industry adoption of Radiance Field methods.

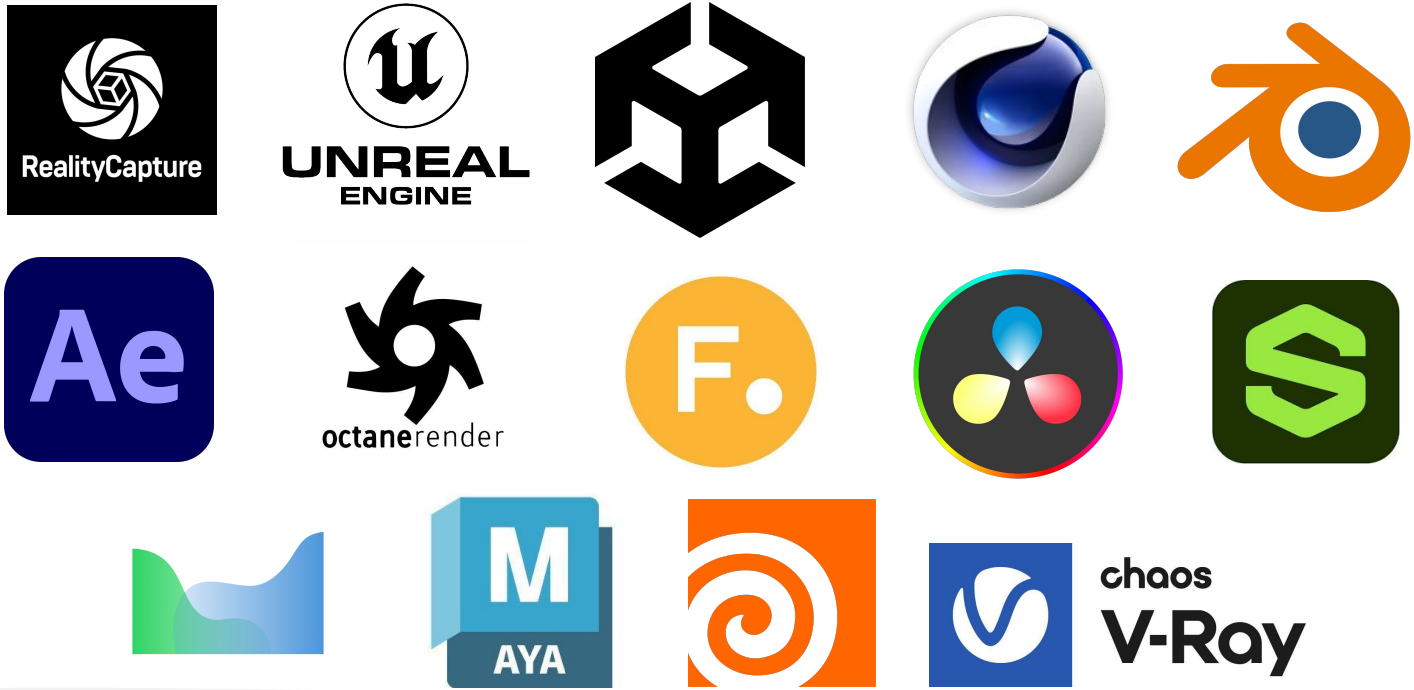
Outputs a .ply file
Produces *.ply files for easy integration into existing 3D workflows.

Compatible with existing libraries
Three.js, Babylon.js, WebGPU

Rapidly Growing Research Interest
19th most cited paper of 2023

Gaussian Splatting Compatibility

Industry standard platforms already support 3DGS.



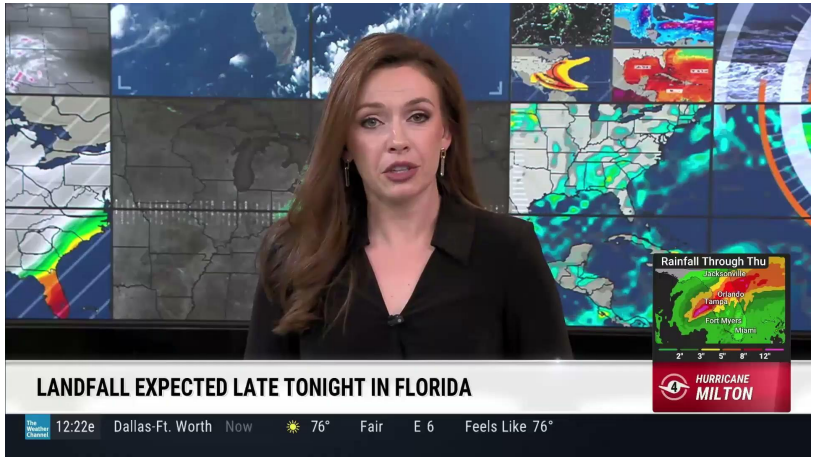
Dynamic Gaussian Splatting

Radiance Field methods already support dynamic reconstructions.

Captures by Infinite Realities

Case Study: The Weather Channel

FloodFX is powered by NeRFs and Gaussian Splatting, combined with Unreal Engine.



Radiance Fields visualize local news stories

“As a meteorologist I can only say that it's been an amazing step forward in translating the forecast. Being able to produce a video depicting the future and actually showing audiences what their location may actually look like has been a game changer when it comes to messaging the dangers associated with storm surge flooding.”

Emmy Award Winning

FloodFX won an Emmy for Outstanding Technical Excellence.

The Rise of Radiance Fields

Radiance Fields, like Gaussian Splatting are accessible, efficient, and cost-effective, making them ideal for widespread adoption.

Low Barrier to Entry

Compatible with any camera for input data creation
Unlocks value from existing photogrammetry datasets
Trains on consumer-grade GPUs and mobile devices
Achieves rapid training times for faster results

Transition Imaging into Lifelike 3D

Industries reliant on 2D imaging are poised to transition to 3D
Foundations for this shift are being established today

Michael Rubloff

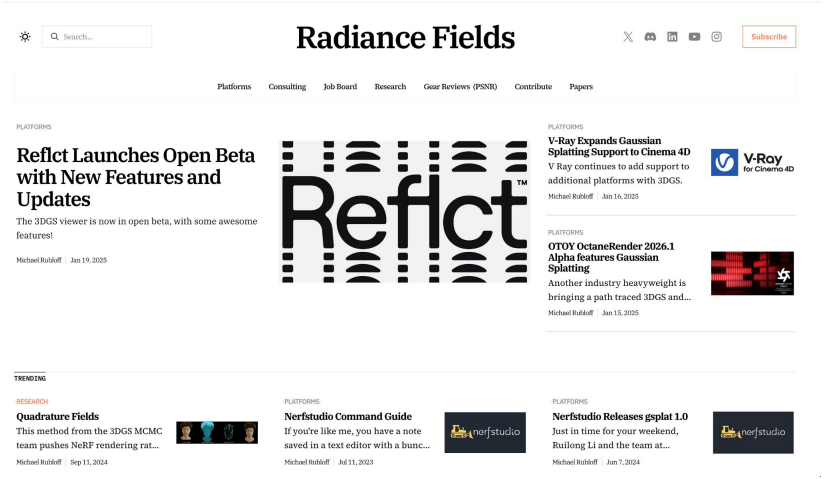
Stay Up to Date

Radiancefields.com catalogs the progression of 3DGS and other Radiance Field Representations

Premier Destination of news for Radiance Fields

Consulting Services for Businesses

Reach top Engineering talent



Random Compressed Gaussian Thoughts

Aras Pranckevičius

Who am I and what I did

At end of 2023 wrote blog posts exploring **3DGS compression**: aras-p.info/blog/2023/09/05/Gaussian-Splatting-is-pretty-cool

- Locality reordering + chunking,
- Data value remapping + quantization within chunks,
- Spherical Harmonics VQ clustering,
- GPU BCn compression for 3DGS data

Made 3DGS viewer/editor for **Unity**: github.com/aras-p/UnityGaussianSplatting

…did nothing related to 3DGS since then!

3DGS: Ready for Standardization?

"Any headline that ends in a question mark can be answered by the word ***no***."

Me: can we have some standard for gaussian splats?
Mom: we have standard at home.
Standard at home: PLY with 248 bytes per point.

3DGS: Ready for Standardization?

That said:

Feels like everything is still moving too fast for standardization.

Why it might be too early

There’s a new paper, *like*, every day. MrNeRF's database has 440 papers today!

3DGS *authoring/interchange* vs *delivery* are very different use cases

- Interchange: PLY is fine? Is itself extensible, somewhat.
- Delivery: is there a need for standard yet?

Do we know that “2D-ish projected gaussian ellipsoid” is a good primitive?

Are we happy with Spherical Harmonics for view dependent color?

“Loosely defined standard”

PLY files are from 1994. But they allow flexible enough data so that 3DGS can use “just a PLY file”, thirty years later.

Likewise, glTF can already express the same.

Q: should there be some standard on glTF attribute names and data types?

KHR_gaussian_splatting is one attempt (lacking SH, compression is not great)

Things to think about

Disk/network size vs. RAM/VRAM size. Both important for different cases!

LOD

Streaming

Compositing multiple 3DGS clouds together

Aside: what people want, from one use case

Unity Gaussian Splatting (2.3k github stars, 270 forks) experience.

What people keep on asking for?

- VR/XR/MR/AR
- Mobile
- Web
  - All of these possible, sometimes hard to do *efficiently*
- Integration with regular 3D content and/or relighting
  - *Very* hard problem!
- Runtime loading of file format produced by <some other tool>
  - ⇧ this speaks to *some wish* for a standard

Note how VR/Mobile/Web is **very** different from “CUDA and Python” in papers!

Gaussian Splatting for Spatial Journalism

A.J. Chavar, Creative Strategist
Nick Bartzokas, Senior Software Engineer
The New York Times R&D

Metaverse Standards Forum
Gaussian Splats Town Hall
January 22, 2025

Our Exploration

Our team focused on recreating people and spaces using lightweight, economical approaches as well as complex methods optimized only for peak quality.

We tested a variety of capture methods and equipment: Mobile phones, GoPros, mirrorless cameras, interval and burst photography, manual photography, video, stabilized camera rigs, multicam rigs, lenses across a range of focal points, found and archival footage, sparse and truncated footage, and intentionally digitally stylized source images.

T R&D

Credit: NYT Newsroom Graphics and R&D

Our Interests

- Photorealism
- Speed
- Ease of capture
- Publishing more and more spatial journalism

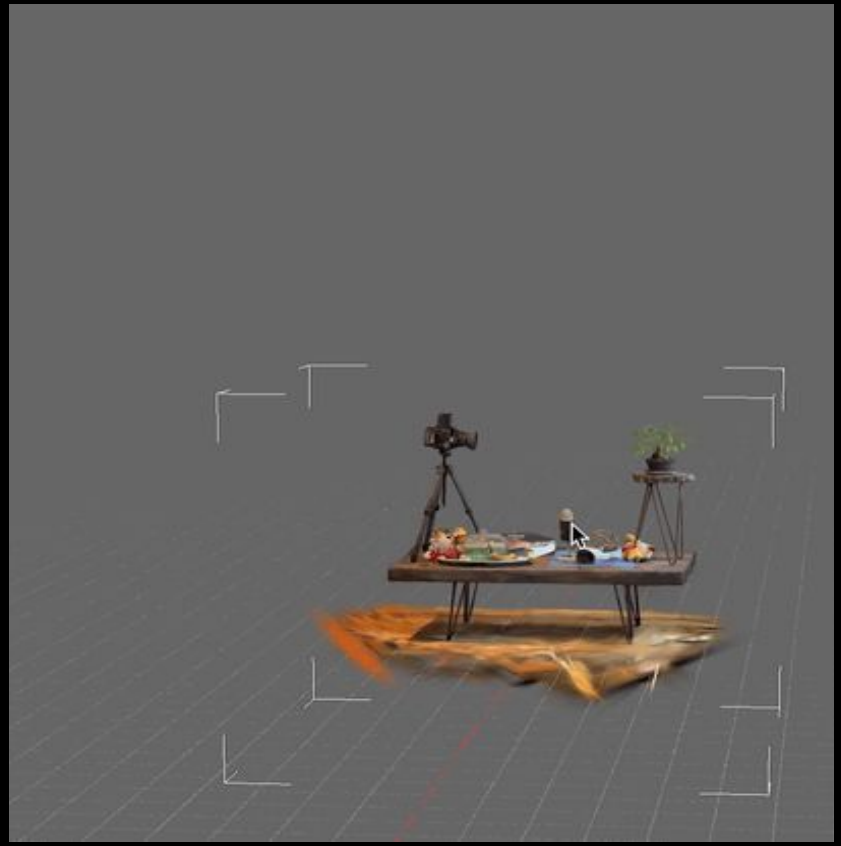
Our Concerns

- Lack of “ground truth”
- Accuracy/Provenance
- Reliability on deadline/in the field
- Signalling use to audience

Credit: NYT Newsroom Graphics and R&D

Our findings

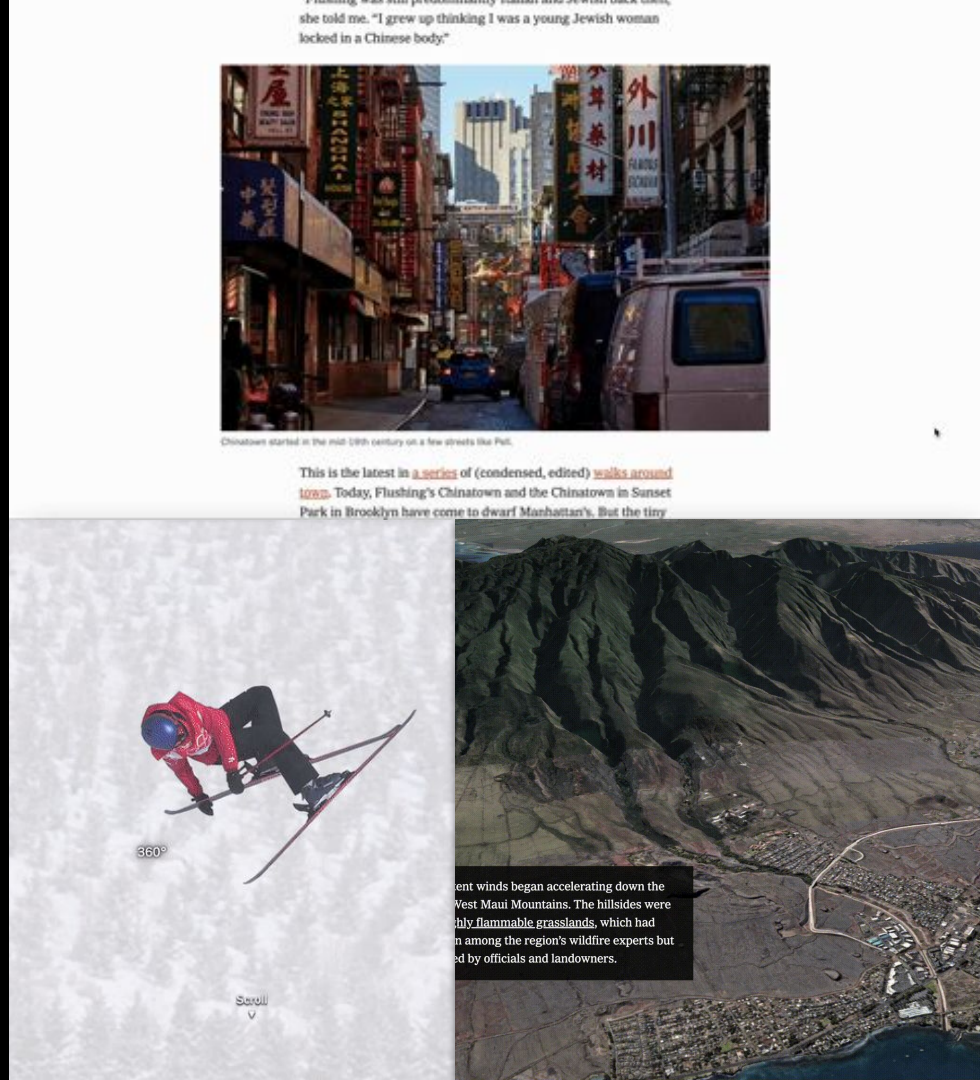
- Faster and less intensive processing
- Possible to work with sparse datasets
- Ability to work with stylized source
- Specific capture patterns have higher success rates to yield “complete” splats
- Specific lenses and camera settings yield better final results, especially combined
- Scaniverse is an impressive field tool



Credit: NYT Newsroom Graphics and R&D

How we build 3D stories

In collaboration with the Newsroom's Graphics desk, we created an in-house tool called "Threebird" for collaboratively authoring interactive 3D articles. With this tool The Times has published stories like these: a walk down Doyers Street in New York, with old photos aligned to a new photogrammetry model; a 3D model of an Olympic gold medal skier, inferred by machine learning from a single 2D photograph; and an in-depth analysis of the Maui fire using Google 3D tiles. With an eye towards the future, we've experimented with Threebird support for XR, NeRFs, and now Gaussian Splats.

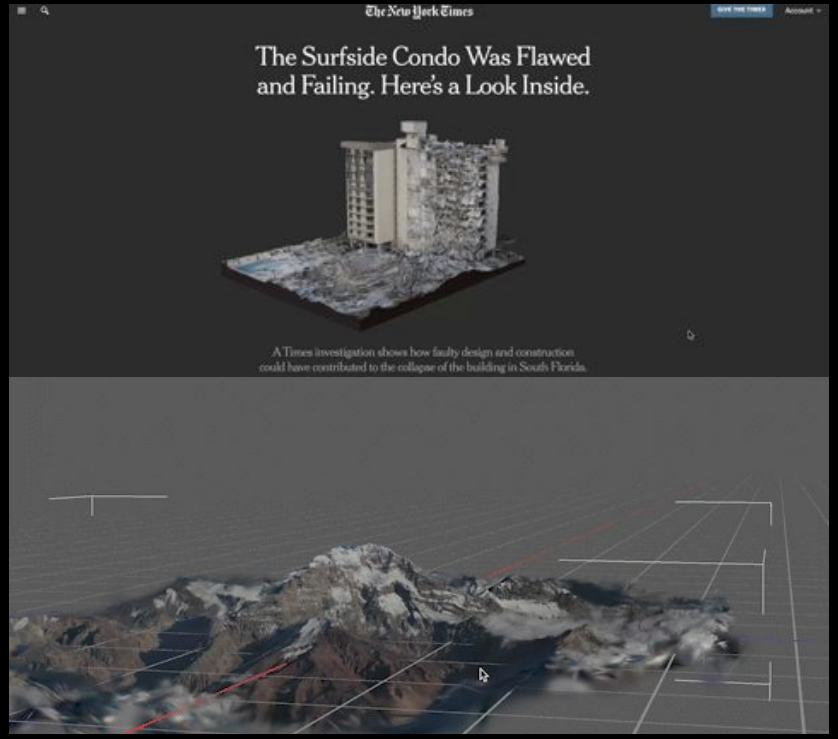


T R&D

Credit: NYT Newsroom Graphics and R&D

Sparse, Drone, Found Footage

The Newsroom and R&D are exploring the use of splats in stories for which we have only sparse found or drone footage and want to reconstruct a 3D scene. In our coverage of the collapse of a Miami condo, we used drone footage and photogrammetry to analyze the aftermath of the collapse. We've been testing similar workflows using splats as in this drone footage of Aconcagua.



Credit: NYT Newsroom Graphics and R&D

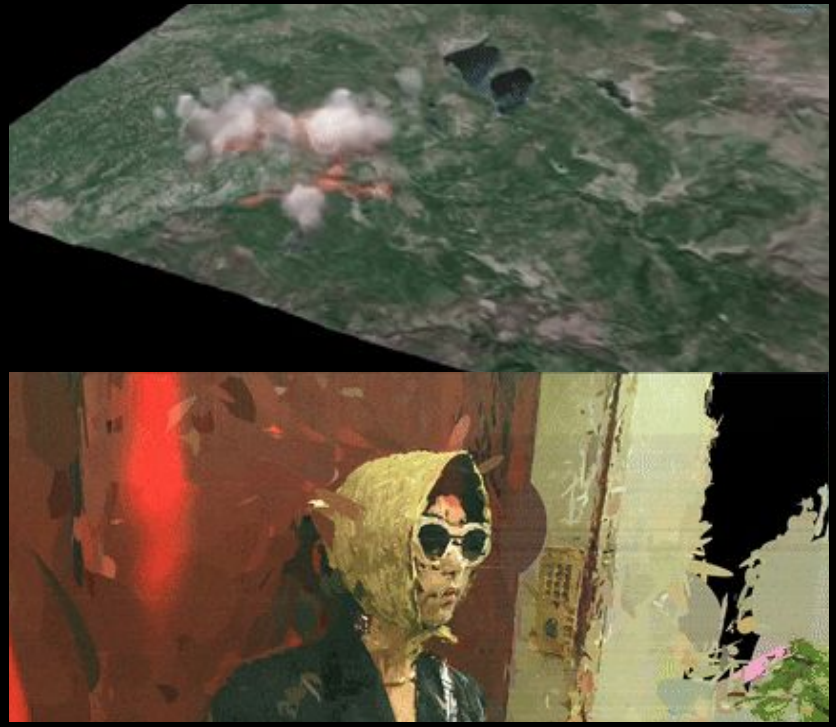
Wider Context with Maps

Threebird supports the Cesium 3D Tiles standard, and as the dev community has demonstrated, splats can fit nicely into the context of 3D maps, so we are experimenting in this space as well.
As an added benefit, the fusion of these two technologies increases confidence in its fidelity to ground truth.

Credit: 3D assets by @kfarr

Styling as Signal

We use styles as signals to our readers that what they're looking at is an illustration, not reality. For instance, when reconstructing 3D models of weather patterns from data, in addition to detailing our methodology in print, we may omit the sky, and render clouds like cotton to make it clear when technology is generating the image. Since splats mimic rather than capture pixels, we're approaching them with the same caution.



Credit: NYT Newsroom Graphics and R&D

Where the Dragons Be

- Interaction: "I've captured a kitchen, but how do I open the refrigerator?"
- Geometry: "I need coherent normals for my shader." (2DGS?)
- Real Scale: "I made a scene from found footage, but are the distances real?"
- Performance: "Will this big beautiful splat render fast on mobile browsers and XR?"

Our Work: rd.nytimes.com

Pushing the Limits of Gaussian Splatting for Spatial Storytelling

A Field Guide To Gaussian Splatting


R&D

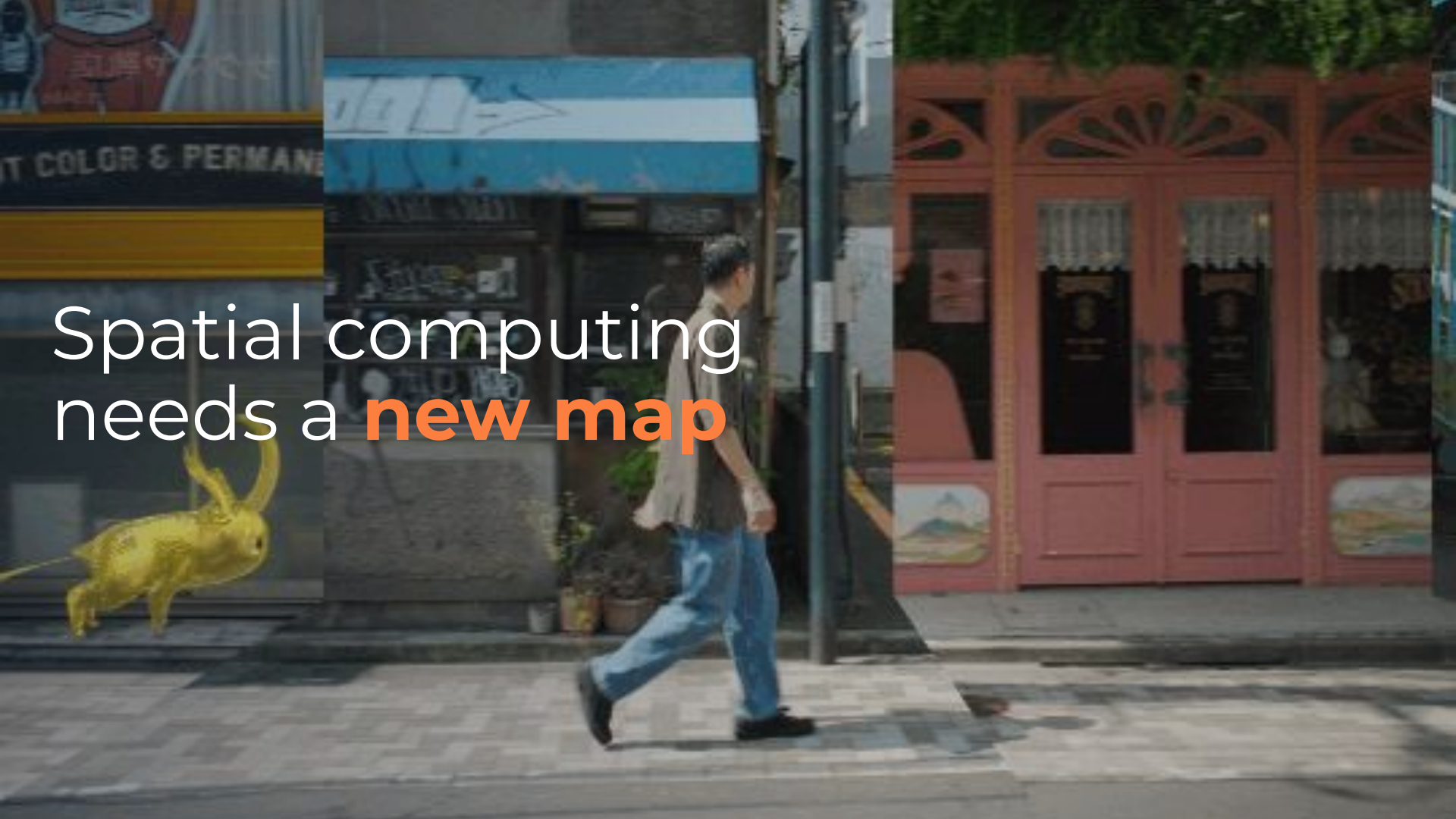
Momentum

- **Nicholas Butko**, Senior Director, Engineering, Niantic, Inc.
- **Nemanja Bartolovic**, Software Engineer & **Ashish Singh**, Product Management, Cloud-AI, RL-Meta
- **Nicolas Moenne-Loccoz,** Principal Research Engineer, ADLR, NVIDIA

NIANTIC | METAVERSE STANDARDS FORUM: GAUSSIAN SPLATS TOWN HALL

Nicholas Butko

Senior Director of Engineering at Niantic

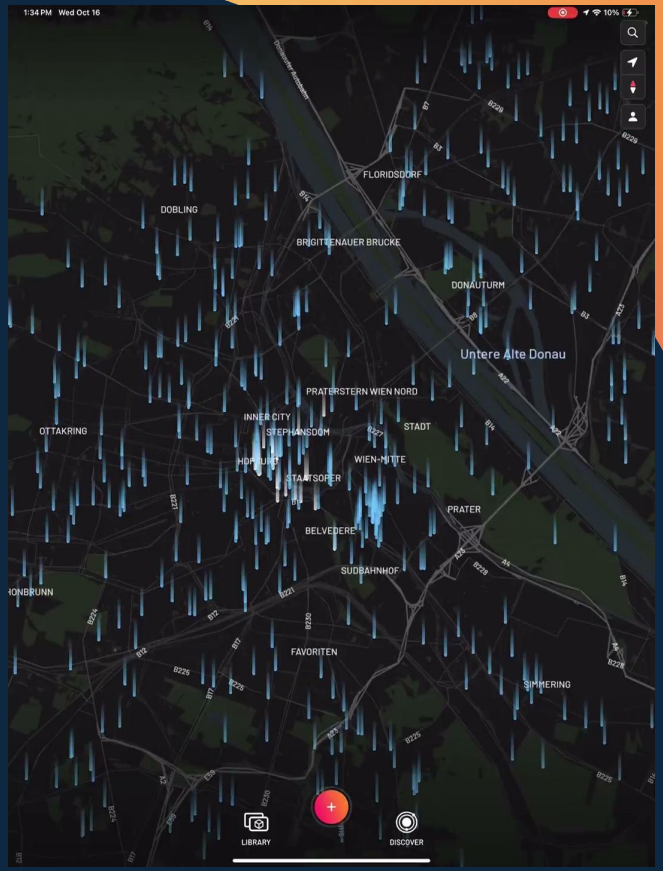

Spatial computing
needs a new map

NIANTIC

SCANIVERSE

Capture the world in 3D

- **Free, fastest and only** on-device Gaussian splat processing
- Scan and share to a **global map** of 1.5M splats, growing every day.
- Joy-scroll **posted splats**
- **Unlimited free** splats
    - **Export splats** for use in interactive 3D content.



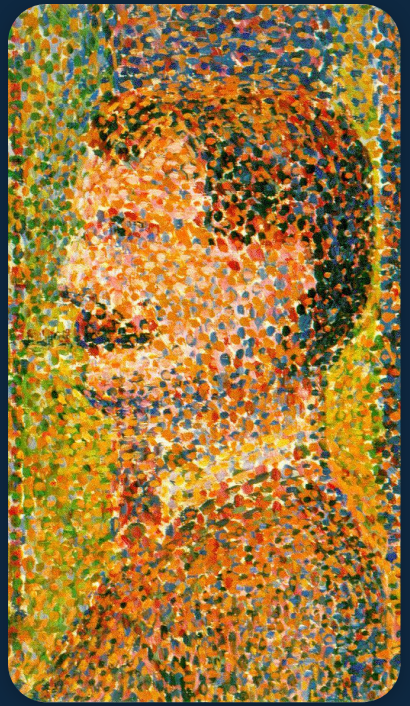
Download Scaniverse for free on iOS and Android

Splats are the New Mesh

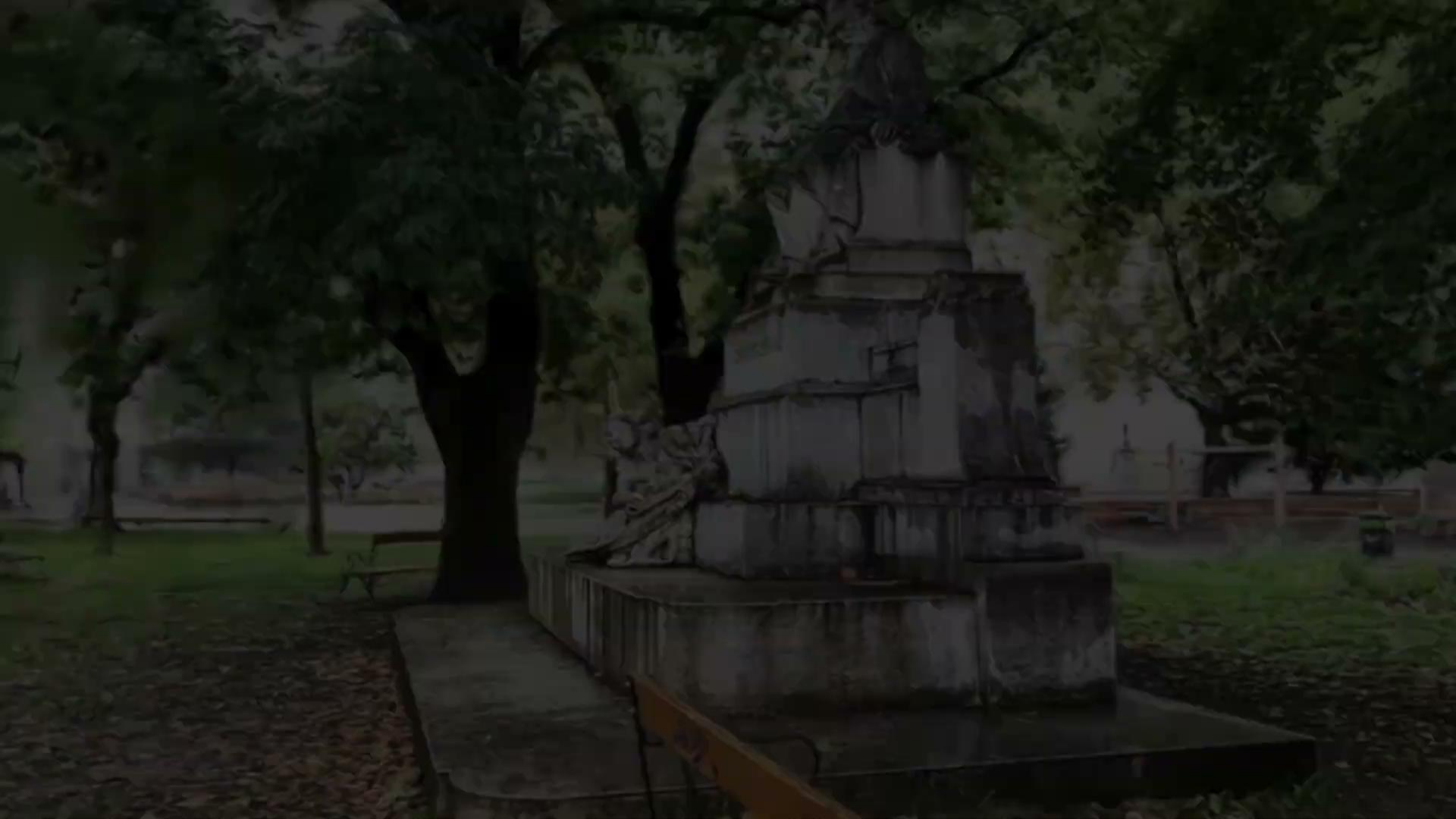
NIANTIC

METAVERSE STANDARDS FORUM: GAUSSIAN SPLATS TOWN HALL

Shape & Shading



Color & Light



“I’ve been working in 3D graphics for 38 years now, and I don’t think we’ve seen anything this transformative since real-time texture mapping in 1991.”

Brian McClendon
VP for Google Maps 2004-2015
SVP Engineering at Niantic

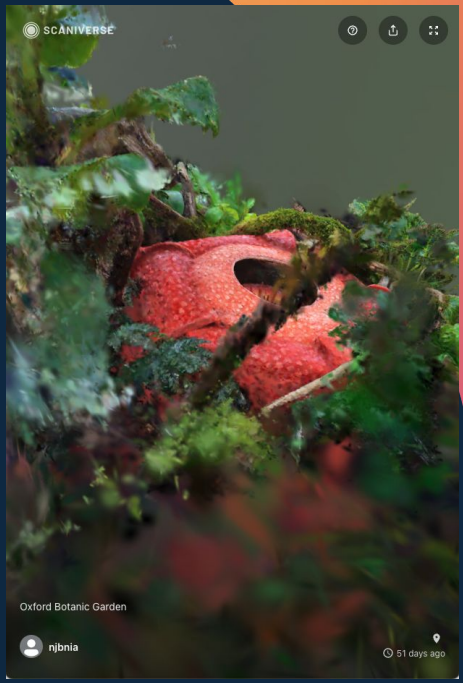
- Meshes have been a staple of interactive experiences for more than 30 years
  - Splats can look much more photo-realistic and immersive than meshes for a given file size.
  - Fundamentally, Splats are just point clouds where the points have extra metadata (size and rotation).
  - Splats can typically be integrated with existing game engines with a couple hundred lines of code.
- Scaniverse makes capturing and exporting splats fast and easy!

Try Wonder Cars at nianticarcade.com

Challenges with Splats

- Splat quality is view dependent
- Splat geometry is not conducive to traditional game engine physics
- Splat rendering can be slow on VR / low powered devices.

- Splat file size can make it difficult to make splats portable and run at scale on client devices ✅



Introducing .spz

- **.spz** is an open source format developed by Niantic to make it faster to upload and download splats, and decrease storage and memory requirements for splats on client devices
- **.spz** uses techniques like fixed-point quantization, log encoding, and libz to compress data without losing image fidelity.

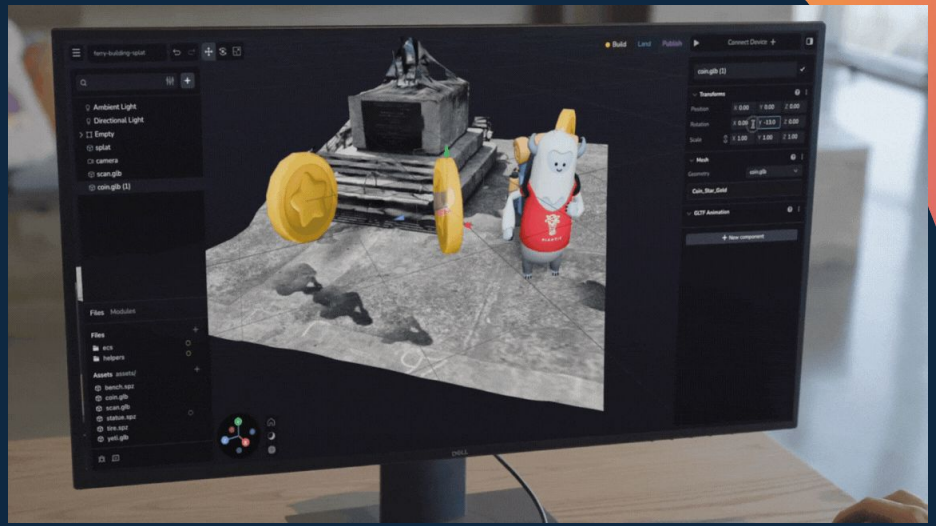
Element	SPZ Format	PLY Format	Size Reduction (%)
Positions	24-bit fixed point integer with adjustable fractional bits	32-bit or 64-bit floating-point	25%–62.5%
Rotation	3 components of a quaternion stored as 8-bit signed integers	4 components of quaternion as 32-bit floats	81.25%
Colors (RGB)	8-bit unsigned integers per channel	Typically 8-bit or 32-bit floats per channel	0%–75%
Scales	8-bit log-encoded integer	Typically 32-bit or 64-bit floating-point	75%–87.5%
Alphas (Transparency)	8-bit unsigned integer	Typically 32-bit float	75%
Spherical Harmonics	8-bit signed integers for coefficients, with 4-5 bits of precision	Varies, but usually stored with higher precision (e.g., 32-bit floats)	75%–87.5%

.spz is free and open to all. Fork, file issues, or submit PRs on Github!


Showcase
Discover
My Likes
Profile

Our proposal: Extend Existing Standards

- Extend GLB format to
  - Embed .spz data
  - Include skybox images for faster rendering
  - Include mesh data for physics
  - Include other meta-data
    - View ranges
    - GPS coordinates



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Gaussian Splatting Representations at Meta

Jan - 2025

Presenters:

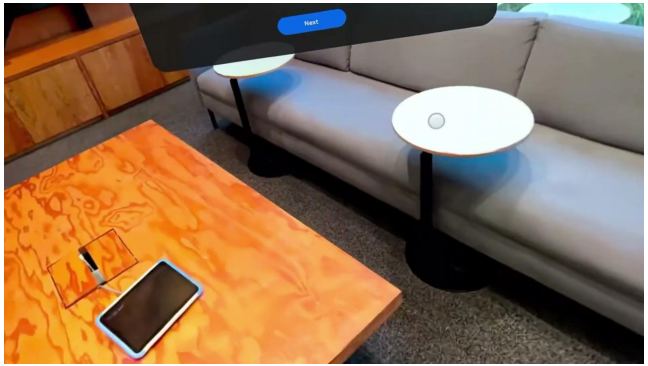
Nemanja Bartolovic - Software Engineer

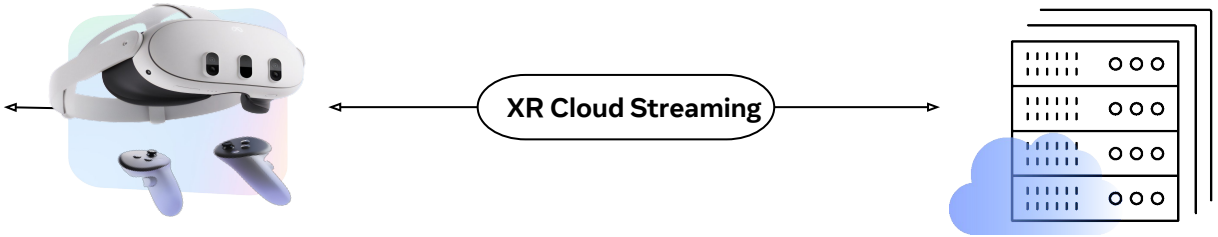
Ashish Singh - PM lead, Cloud - AI

Agenda

1. Current State of 3D Gaussian Splatting at Meta
2. Pipeline overview
3. Opportunities for interoperability

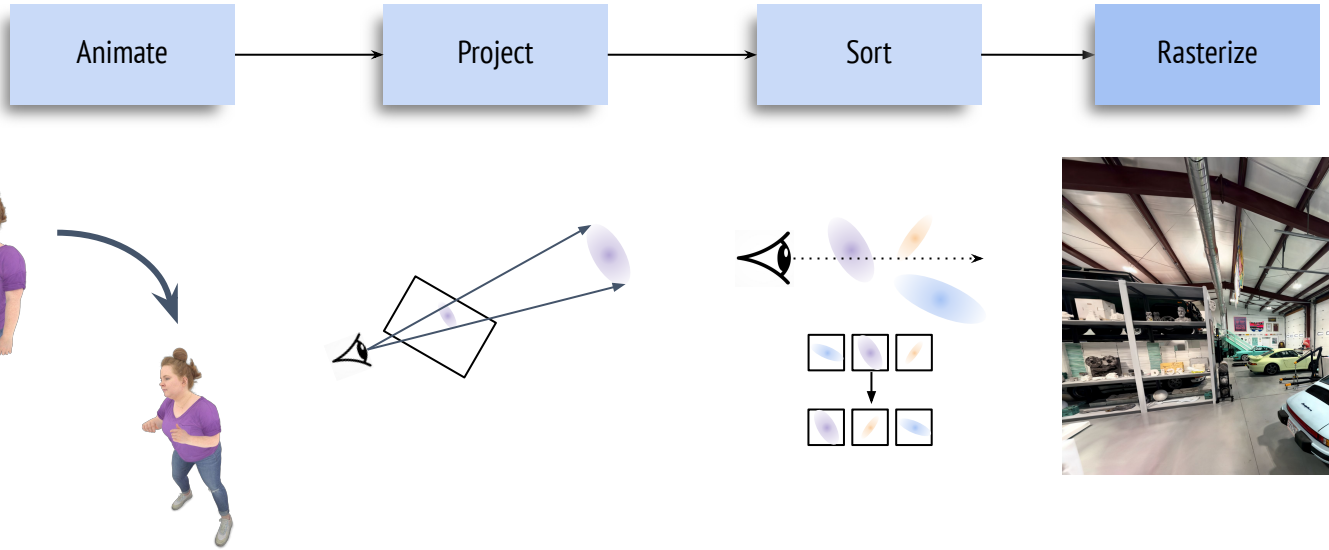
3D Gaussian Splatting, On-device and Cloud rendered





Core Pipeline Overview

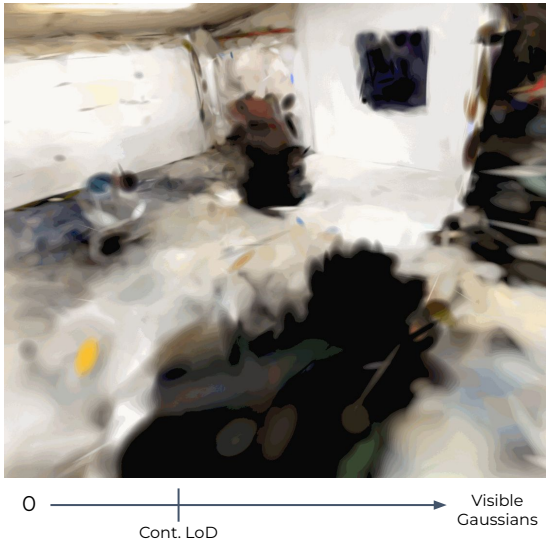
- Different variants across use cases and platforms

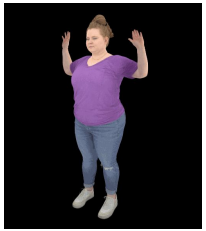


File Format Considerations

- Intrinsic data qualities
  - Rendering algorithm adapts to the **training** or runtime optimizations
  - Kernel type, sorting criteria, LDR vs HDR…
  - Continuous LoD

- Handle **dynamic** content naturally
  - Keyframed, skinned or procedurally animated
    - Example: 3D gifs





File Format Considerations

- **Compression**
  - Plethora of academic work in this domain
  - Per-primitive quantization similar to .spz
  - Per-attribute codebook/texture compression
  - Necessary for limited bandwidth scenarios

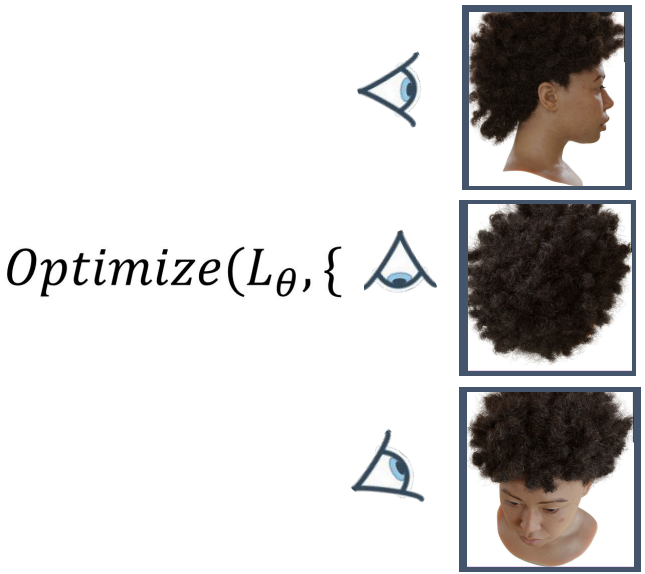
- Keep the options **flexible**!
  - We are still in an early stage

Thank you

Unifying 3D Gaussian Particle Rendering

Nicolas Moenne-Loccoz

3D Scene Reconstruction



$$Optimize(L_\theta, \{ \quad \}) \rightarrow \theta^* \quad : \quad L_{\theta^*}(\quad) =$$

2020 – NeRF

Implicit MLP representation

2023 – 3DGS

Explicit radiative 3D Gaussian particles

2024 - 3DGS Follow-up

StopThePop, 3DGRT, EVER, 3DGUT,...

Radiative 3D Gaussian Particle Clouds

- Explicit 3D definition :
  - position
  - scale
  - rotation

- Modulated Gaussian Density kernel function

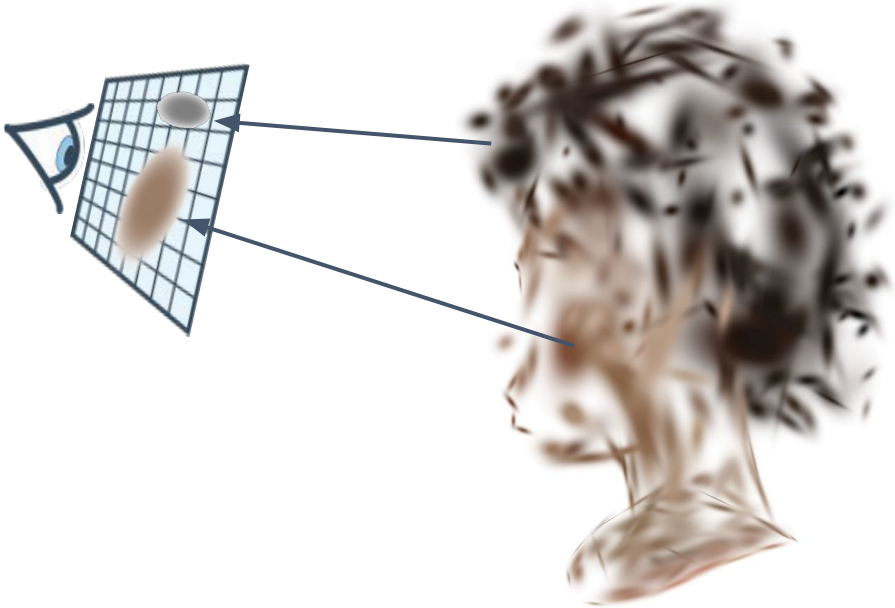
- Spherical Harmonics radiative function

- Volumetric rendering
  - In-order particle radiance blending

3D Gaussian Splatting (Rasterization)

3DGS

- 2D projected Gaussian Density function
- Tile-based particle ordering
- View-based radiance



3D Gaussian Splatting

3DGS

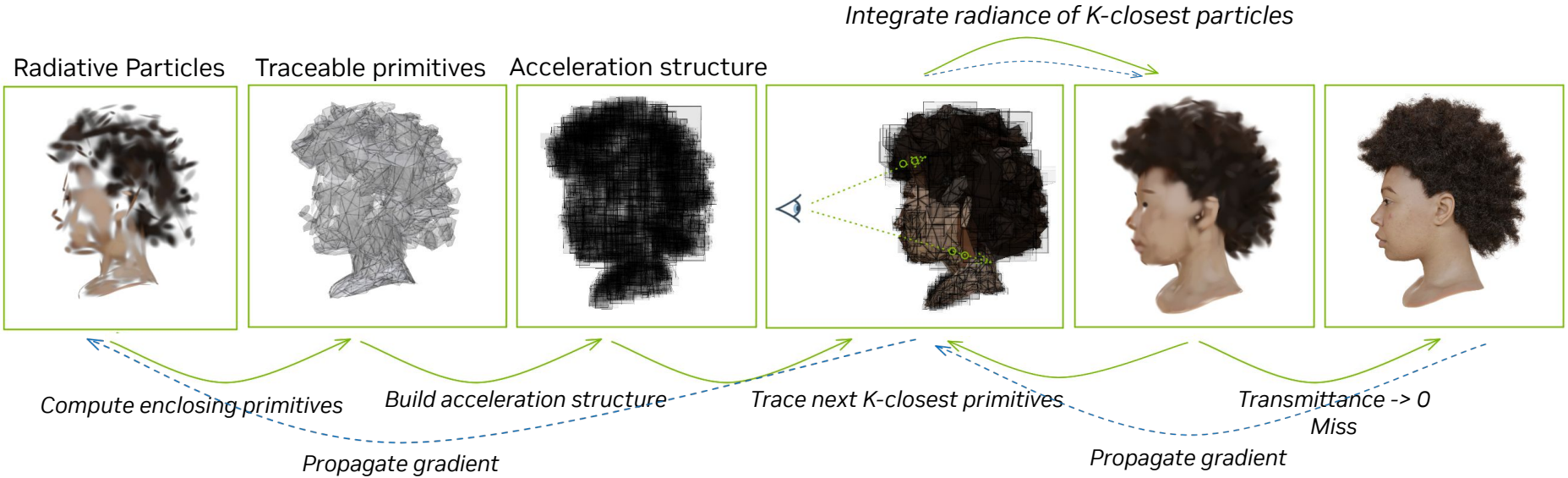
- **REALLY fast and accurate**

- **LIMITED Rendering application**:
  - Non-linear sensors support
  - Secondary rays (reflections, refraction…)

3D Gaussian Ray Tracing

3DGRT

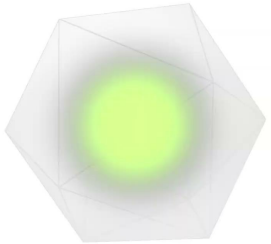
3DGRT Pipeline Overview

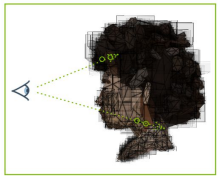


3D Gaussian Ray Tracing

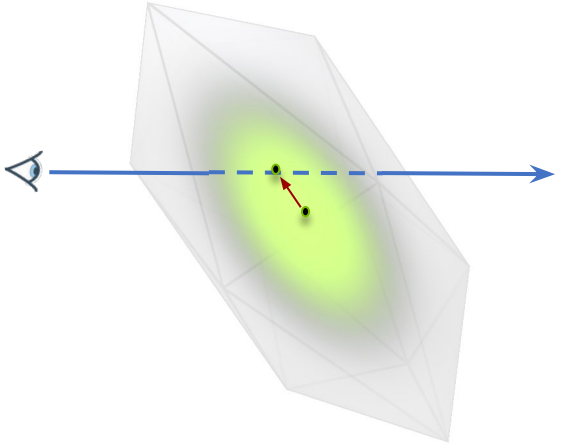
3DGRT

- Traceable primitive
  - Instance AABB enclosing the clamped kernel
  - Proxy-mesh envelope : Icosahedron





- Hardware accelerated in order ray-particle intersection
  - Sampling the intersection segment
  - Single sample : point on the segment maximizing the response

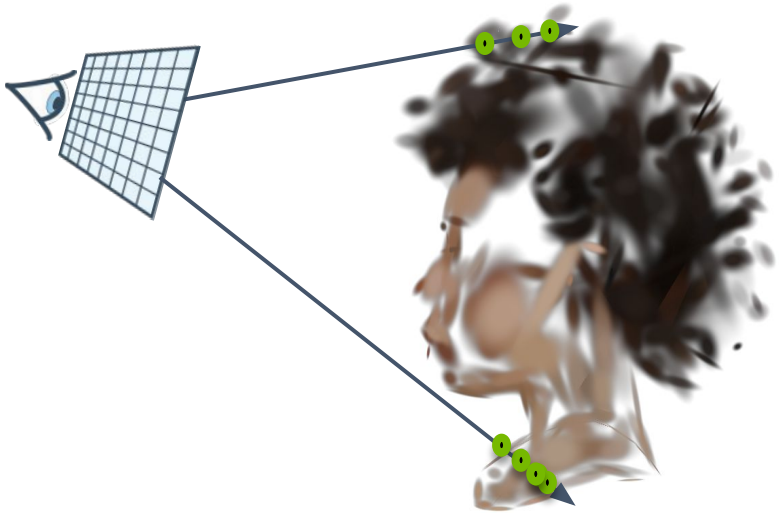


3DGRT versus 3DGS

3DGRT

- 3D **Ray-based** front-to-back particle radiance blending
  - 3D Gaussian density along the ray
  - Exact blending order of the particle along the ray
  - Ray-based radiance

- **Tracing a 3DGS optimized scene is not an option**



3D Gaussians Ray Tracing

- **Fast and accurate**
- **Unlock rendering use-cases**
- **But not 3DGS fast** :
  - Rendering ~4x slower
  - Optimization >5x slower

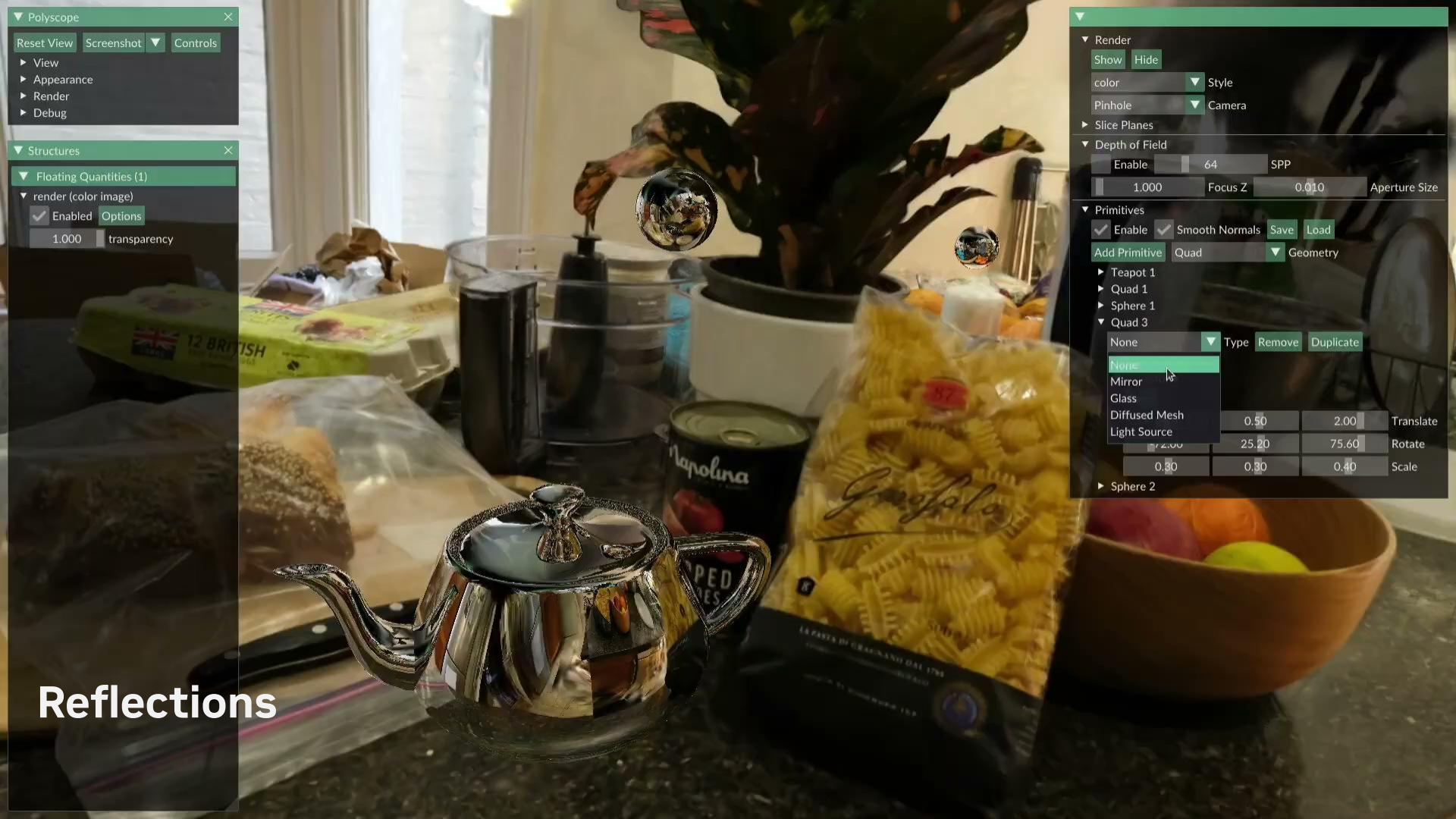
3DGUT : Unifying 3DGS with 3DGRT

3DGUT

- Distortion aware splatting
  - Unscented transform covariance projection
- 3D ray-particle intersection
- Per-ray particle ordering
  - Multi-layer alpha blending

- **REALLY fast, similar rendering as 3DGRT**
  - >2x faster than 3DGRT

Depth of Field


Polyscope
Reset View
Screenshot
Controls
View
Appearance
Render
Debug
Structures
Floating Quantities (1)
render (color image)
Enabled
Options
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Hide
color
Style
Pinhole
Camera
Slice Planes
Depth of Field
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Aperture Size
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Enable
Smooth Normals
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Add Primitive
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Geometry
Teapot 1
Quad 1
Sphere 1
Quad 3
None
Type
Remove
Duplicate
None
Mirror
Glass
Diffused Mesh
Light Source
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2.00
Translate
25.20
75.60
Rotate
0.30
0.30
0.40
Scale
Sphere 2
Reflections


Polyscope
Structures
Render
Show
Hide
color
Style
Pinhole
Camera
Slice Planes
Depth of Field
Enable
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SPP
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Aperture Size
Primitives
Enable
Smooth Normals
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Duplicate
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Transform
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0.30
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Translate
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0.00
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Rotate
1.00
1.00
1.00
Scale
Refraction


Polyscope
Reset View
Screenshot
Controls
View
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Camera Style
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Up Direction
Z Front
Front Direction
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Smooth Normals
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Duplicate
Properties
Transform
Reset
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0.10
3.10
Translate
-72.00
-180.00
93.60
Rotate
0.50
0.50
0.50
Scale
Non-linear sensors

Unified 3D Gaussian particle rendering

3DGRT / 3DGUT

- Accelerate 3DGRT
  - Rasterized primary rays
  - Traced secondaries
- **Tracing / Splatting agnostic scene**
- *3DGRT & 3DGUT are going to be open sourced*

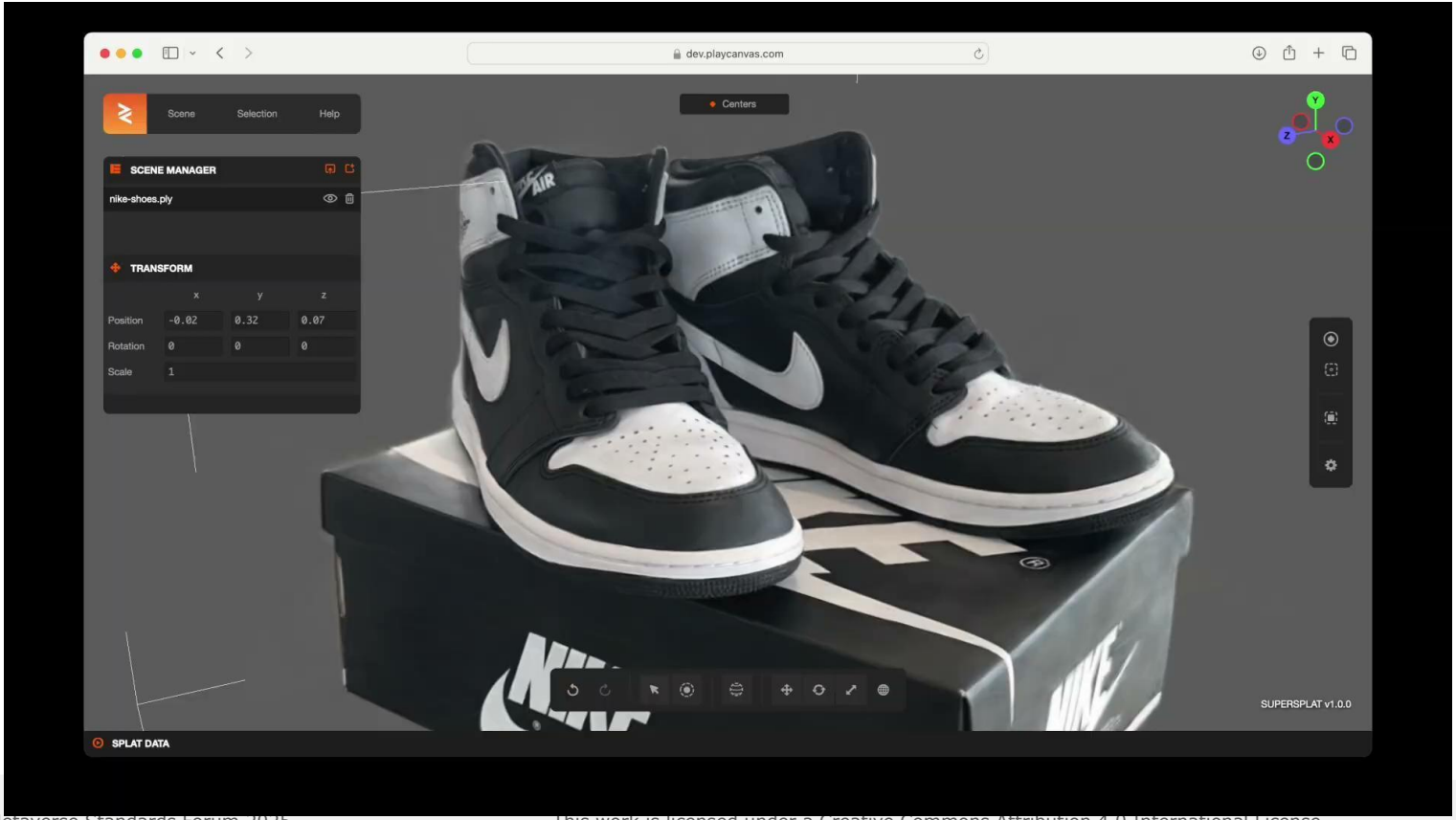
Metaverse
STANDARDS FORUM™

Q&A

Web

- **Will Eastcott**, CEO & Co-founder, PlayCanvas
- **Cedric Guillemet**, Senior Software Development Engineer, Microsoft
- **Thomas Richter-Trummer**, Co-Founder & CTO, Arrival.Space
- **Yoshiharu Sato**, Founder & CTO, Waldek Technologies


PLAYCANVAS
PlayCanvas, SuperSplat and Views on Standardization
Will Eastcott
Creator - PlayCanvas
Metaverse Standards Forum | January 22, 2025
Made with PlayCanvas



GARAGE SCENE BY SIMON BETHKE

Uncompressed PLY
Bytes per splat

Name	Format	Bytes
Position	3 x float	12
Orientation	4 x float	16
Scale	3 x float	12
Opacity	1 x float	4
Spherical harmonics	48 x float	192
Total		**236**

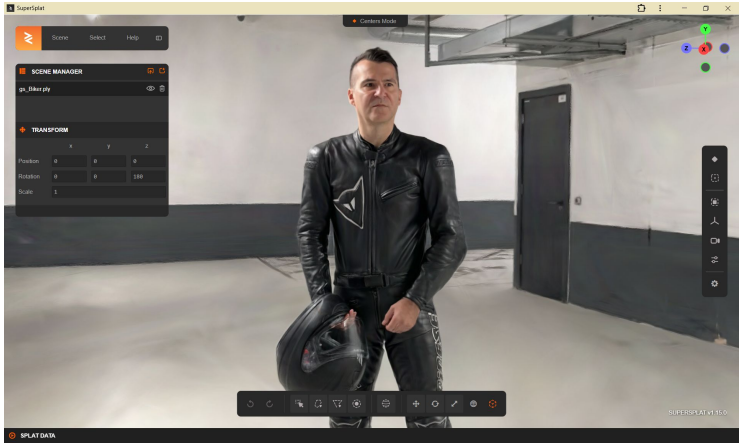
Compressed PLY
Bytes per splat

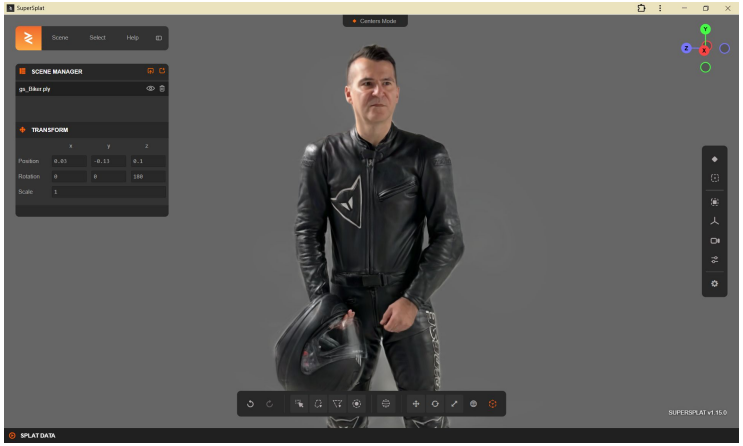
Name	Format	Bytes
Position	uint32 (11, 10, 11)	4
Orientation	uint32 (2, 10, 10, 10)	4
Scale	uint32 (11, 10, 11)	4
Color	uint32 (8, 8, 8, 8)	4
Chunk Data	18 x float / 256	0.3
Total		**16.3**

(Optional) Spherical Harmonics

Name	Data Format	Bytes
Band 1	3 x 3 bytes	9
Band 2	5 x 3 bytes	15
Band 3	7 x 3 bytes	21
Total		**45**

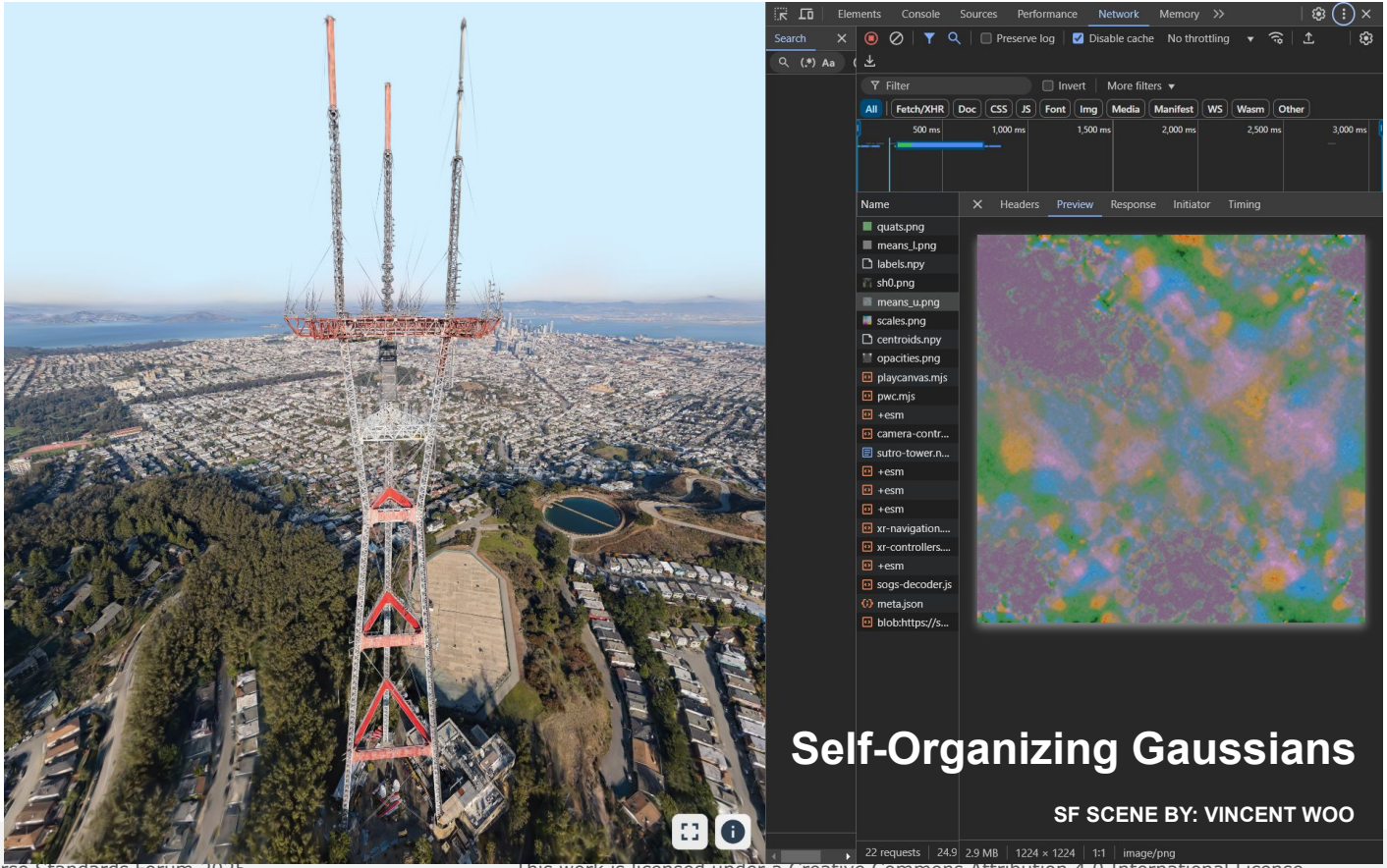
Example Biker Scene (scanned with Luma so no SH):





Uncompressed PLY: 70MB
Compressed PLY: 16MB

And after background removal: 2.5MB



PlayCanvas

Web Graphics Creation Platform

Verified

590 followers | London, UK | https://playcanvas.com | @playcanvas | company/playcanvas

Pinned Order updated. Customize pins

engine Public
Powerful web graphics runtime built on WebGL, WebGPU, WebXR and glTF
JavaScript 9.9k 1.4k

editor Public
Issue tracker for the PlayCanvas Editor
163 28

supersplat Public
3D Gaussian Splat Editor
TypeScript 1.8k 168

model-viewer Public
3D Model Viewer supporting glTF and 3D Gaussian Splats
TypeScript 473 72

web-components Public
Web Components for building declarative PlayCanvas applications
TypeScript 13

react Public
Build 3D apps with React
TypeScript 13 2

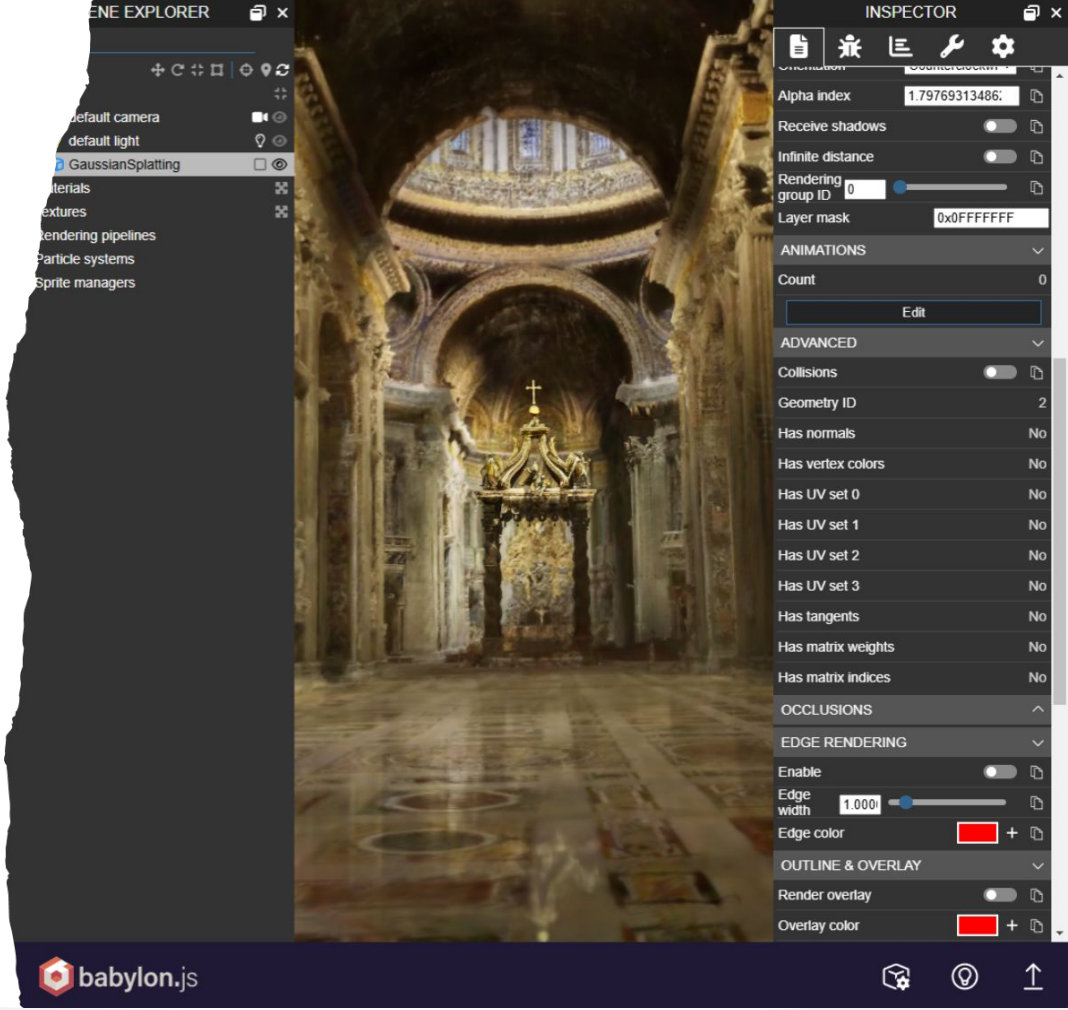
PLAYCANVAS

Thanks for listening!

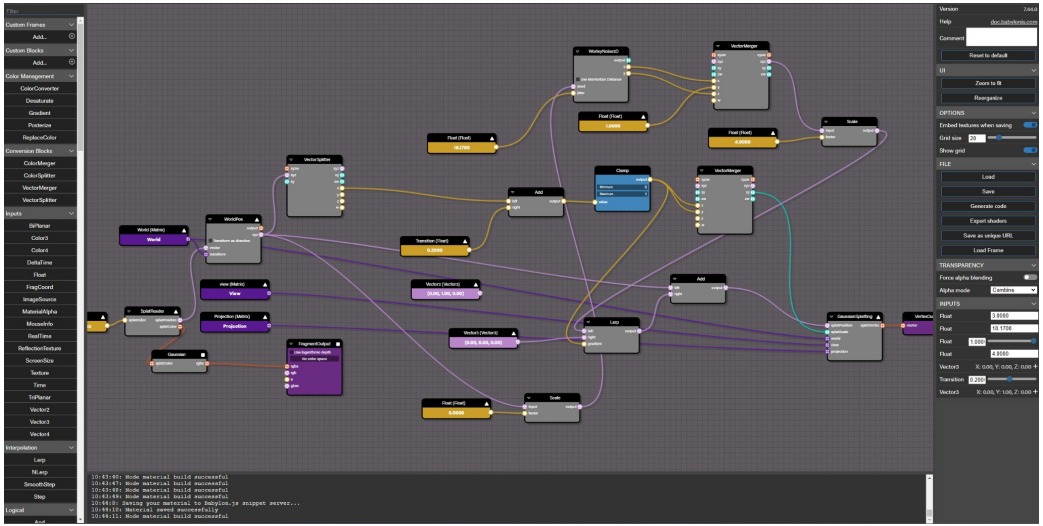
PlayCanvas Editor - https://playcanvas.com
PlayCanvas Engine - https://github.com/playcanvas/engine
SuperSplat - https://github.com/playcanvas/supersplat

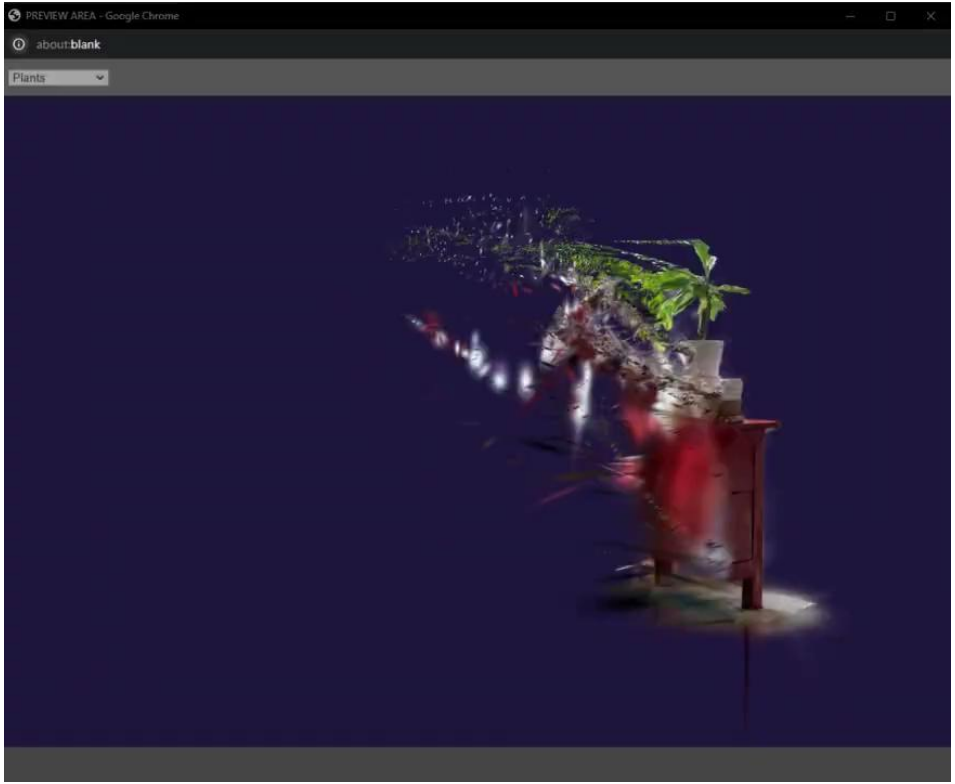
Cedric Guillemet - Microsoft
Senior Software Engineer

Gaussian Splatting With Babylon.js



- Tools and engine
- Exporter/sandbox/nme/runtime view
- Standard pipelines
- Fast iterations, open
- Help adoption of 3D on the web

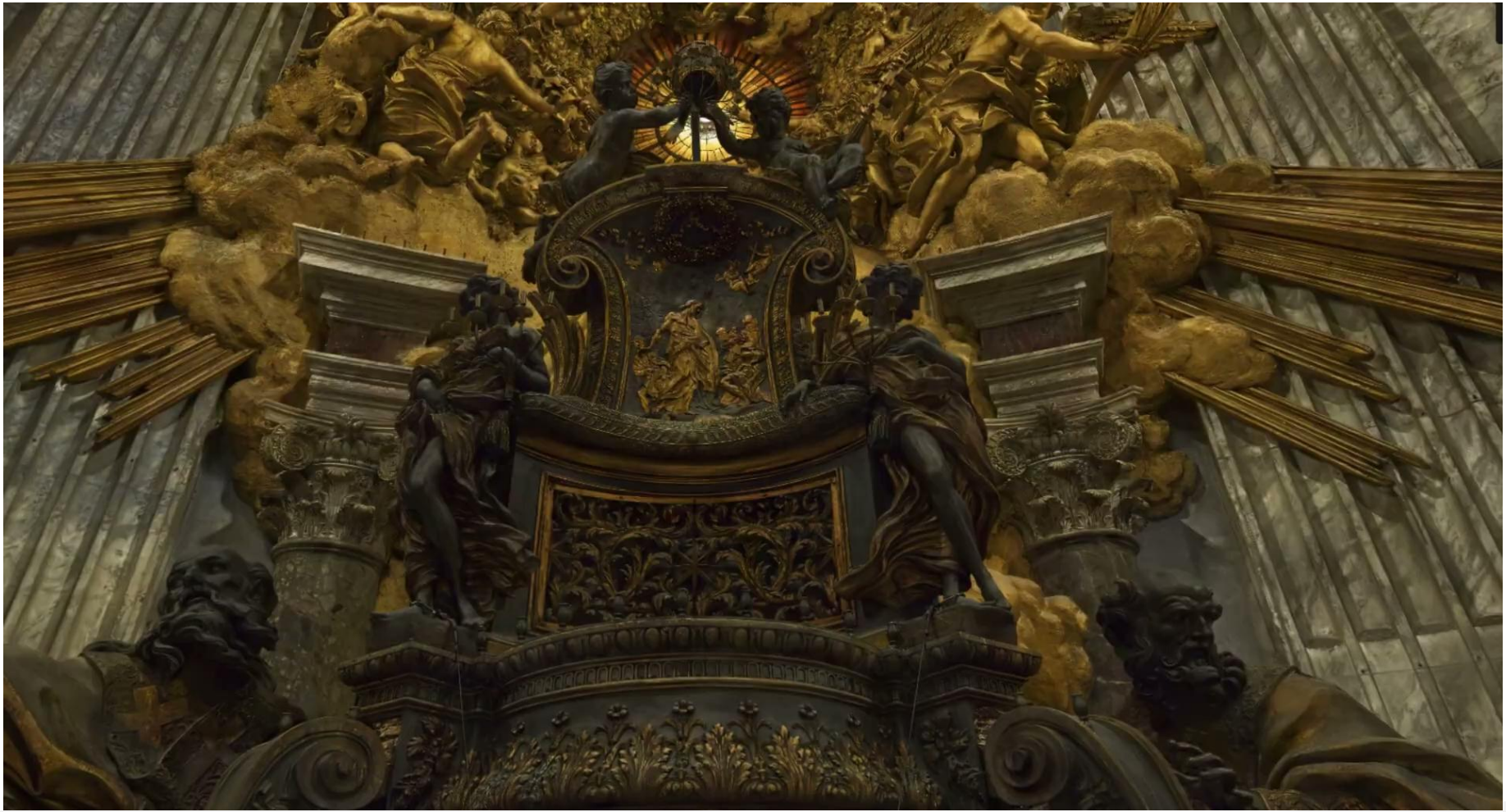




https://nme.babylonjs.com/#T8PN5T#2

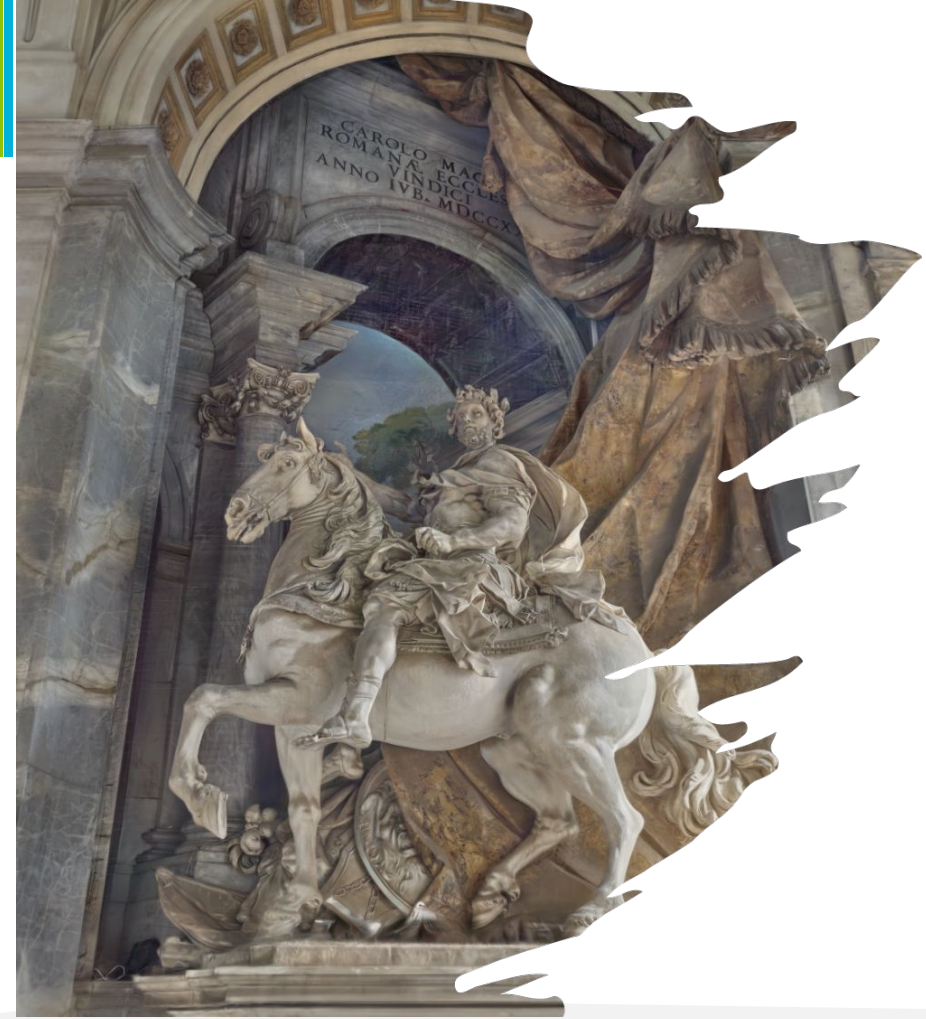
St. Peter's Basilica replica

- used compressed .ply then .SPZ because of SH
- simple pipeline with known coordinate system
- 3-5M splats per scene
- Mixing with rest of the engine
- https://virtual.basilicasanpietro.va/



Lessons learned improvements

- Coordinate system
- Color space
- Data/compression/encoding
- Reference for encoding values
- Reference rendering



Links

- Charlemagne monument
- https://virtual.basilicasanpietro.va/it/basilica-viewer/charlemagne-monument
- Behind the scene
- https://apnews.com/article/vatican-microsoft-basilica-artificial-intelligence-c37d066dc7455ffacece2457c4f8e1a1
- Announcement video
- https://www.youtube.com/watch?v=5dQI_TXYJbU

Thank you

Building an immersive future with Gaussian Splatting

Yoshiharu Sato’s presentation can be found at:

https://www.canva.com/design/DAGbyqwnWp4/EZP8E38_GJWjESjVPdRC-g/view?utm_content=DAGbyqwnWp4

GSplats on the Immersive Web

Compression, Streaming and Collision in a Collaborative Web Based Environment

Thomas Richter-Trummer | CTO Arrival.Space

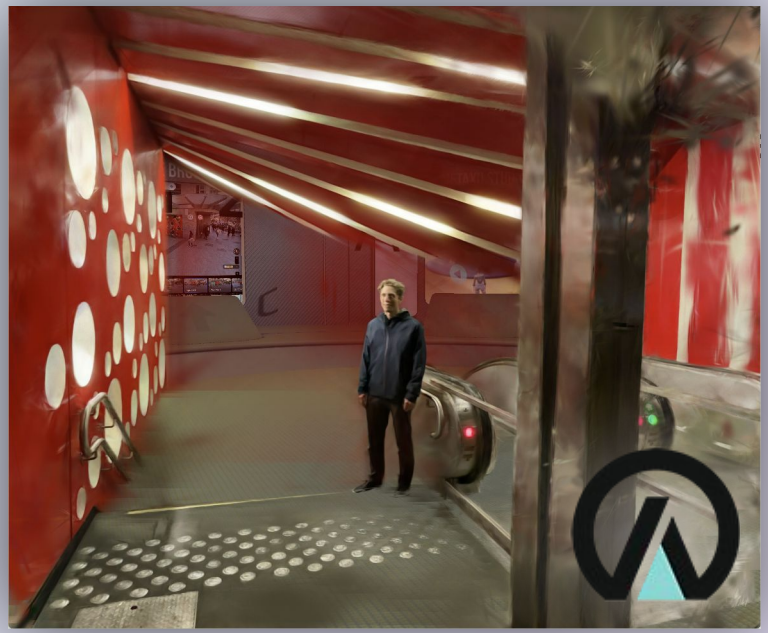
GSplats and Arrival.Space

Arrival.Space

- Immersive multi-user social platform for uploading, viewing and sharing Next-Level-Content
- Released first GSplat support at **AWE 2023**

Feature Highlights:

- Scalable **Compression**
- LOD **Streaming**
- **Collision** Generation
- Optimized for Desktop, Mobile, and VR



Arrival.Space - AWE 2023
live.arrival.space/debrouckere

GSplats Compression

Two-Stage Point Compression Pipeline

1. **Quantization-Based Compression**
   (e.g., SPZ, Compressed PLY)
   - Reduces precision, before gzip
   - *Visually lossless*
   - Compression ratio: **4–10**

2. **Covariance-Based Splat Merging**
   - Merges small details, preserving larger structures
   - *Lossy compression*
   - Compression ratio: **50+**

Result

- Large scenes remain accessible on lower-end devices
- Ideal for distance-based Level of Detail (LOD)

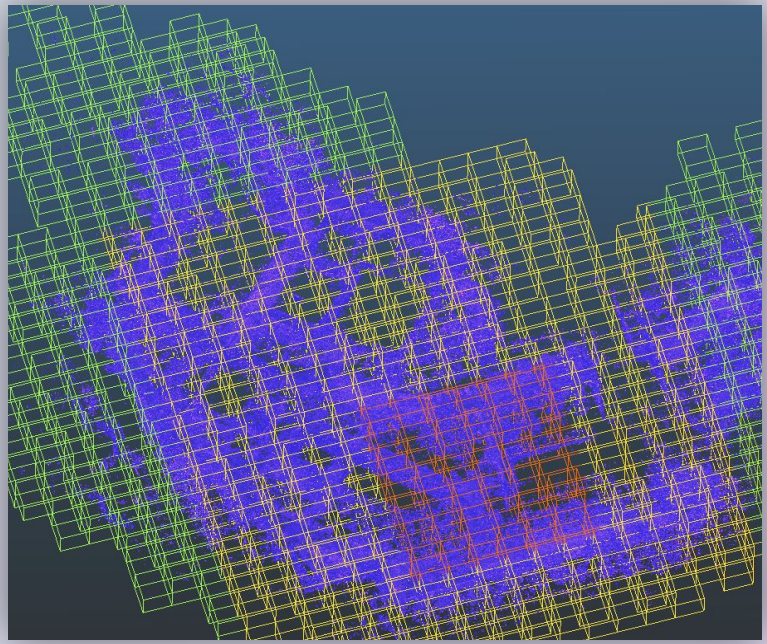
GSplats Streaming

Preprocessing

- Split the scene into manageable chunks
- Generate multiple LOD levels for each chunk

Runtime

- Frustum-cull chunks
- Choose LOD based on viewer distance
- Sort chunks by distance (back to front)
- Perform low-bit (non-linear) bucket sorting of Gaussian splats



Result

- **Reduced Data Transfer:** Only necessary geometry is streamed
- **Constrained Memory and Fast Rendering:** Maintains real-time performance with consistent visual fidelity across varying scene sizes

GSplats Collision

Process:

- Remove Outliers (SOR)
- Calculation Normals (Dirichlet Method)
- Reconstruct Poisson Surface
- Discard Low-Density Faces
- Export as GLB
- Load as static `TriangleMeshShape`

Result

- Collision generated **solely from GSplat data**
- Works for Isolated objects and large scenes

👉 arrival.space/cathedral-cave

Live Demo

👉 arrival.space/campus

- 10 GB of Raw Splat Data
- Scalable Compression
- Chunk-Based LOD
- Auto generated Collision

- Runs on Meta Quest 3 and Mobile

GSplat Dataset from *Bernhard Kerbl et al.* "A Hierarchical 3D Gaussian Representation for Real-Time Rendering of Very Large Datasets"

Geospatial & Digital Twins

- **Renaud Keriven**, Distinguished Engineer, Bentley Systems
- **Jason Sobotka**, Software Engineer, Cesium
- **Ladislav Horký**, CTO at Melown Technologies, Hexagon
- Q&A
- **Konrad Wenzel**, Director, Stuttgart R&D Center and **Jean-Philippe Pons**, Sr. Principal Software Development Engineer, Esri
- **Takayuki Murayama**, Senior Director & **Talha Khalid**, Global Development Manager, EARTHBRAIN
- **Emeric Beaufays**, Geospatial and 3D Specialist, Founder & Software Engineer, JDULTRA

Metaverse Standard Forum
Gaussian Splats: ready for standardization?

Renaud Keriven – Bentley Systems - iTwin Capture

Bentley


Bentley Systems
The Infrastructure Engineering Software Company

iTwin® Capture

iTwin Capture democratizes access to reality data and facilitates the construction of digital twins by all infrastructure practitioners. It is a full reality modeling solution enabling users to capture, manage, share, and extract insights from reality data to add real-world insights to digital twins.

Capabilities

- Capture, create and enhance reality data
- Manage, catalog, and share reality data
- Validate and extract related insights
- High-fidelity 3D engineering-ready reality meshes
- High-scalability processing power
- Single data environment from capture to reality data delivery
- Open, connected, and integrated with Bentley and third-party applications

News

- **AI for Reality Data**
- **iTwin Reality Management**
- **Gaussian Splats**

Bentley

Infrastructure Digital Twins
When are Gaussian Splatting be preferred to meshes?

1. Acquiring thing structures: telecommunication, electric utilities, construction, bridges, …

2. Realistic rendering: context around a design project

3. Faster : adjustable speed

Bentley

Infrastructure Digital Twins
For which applications are GS usually good enough?

- Measurements: distances and surfaces (not volumes with standard GS)

- AI based analysis

GS are of course better than meshes for details not captured by meshes!

Infrastructure Digital Twins
Gaussian Splats standardization?

It is a requirement!

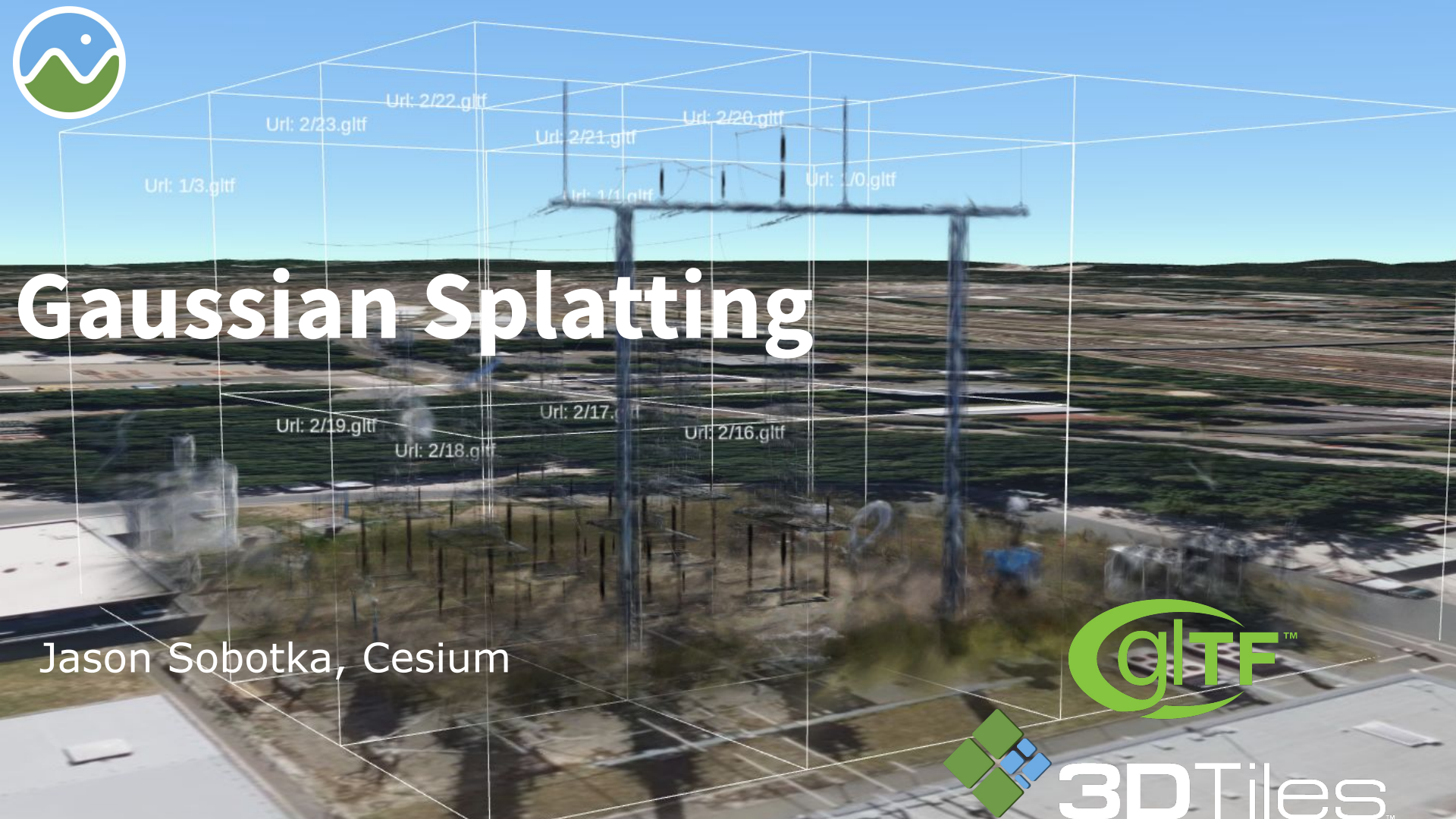
- Large collaborative projects
- Long-term projects that must last

Are we ready for it?

- 3D tiles, as a format for tiling and LODs, are already standard and used for meshes and point clouds.
  → would facilitate R&D in LOD creation and rendering
- glTF extension: this is the question!
  → would facilitate R&D on GS compression

Demo

Bentley



Gaussian Splatting

Jason Sobotka, Cesium

glTF™

3DTiles

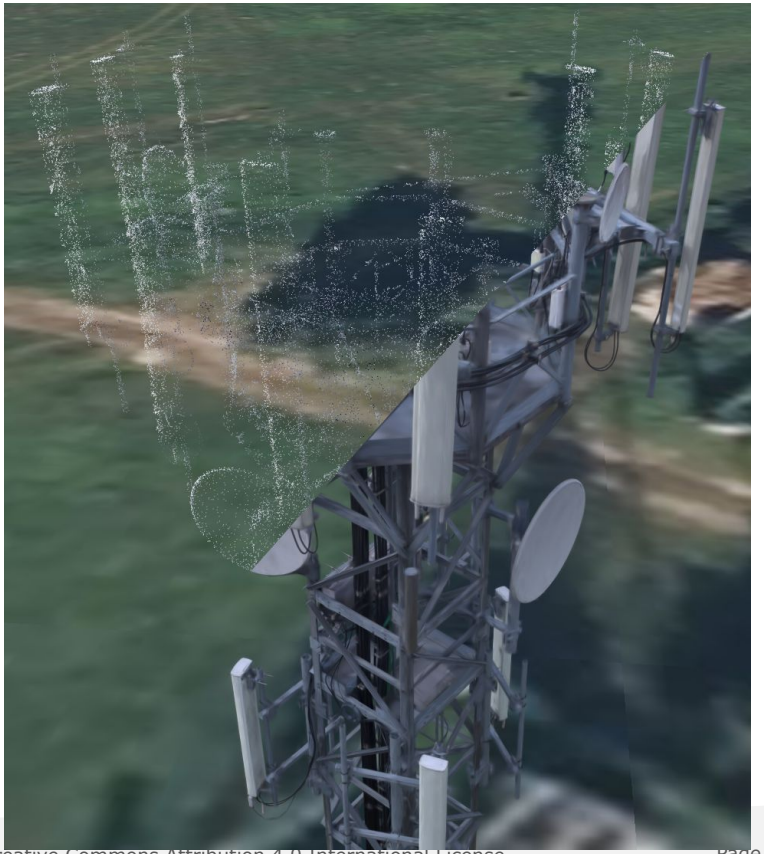
Our Approach

- Keep It Simple
- Open Standards

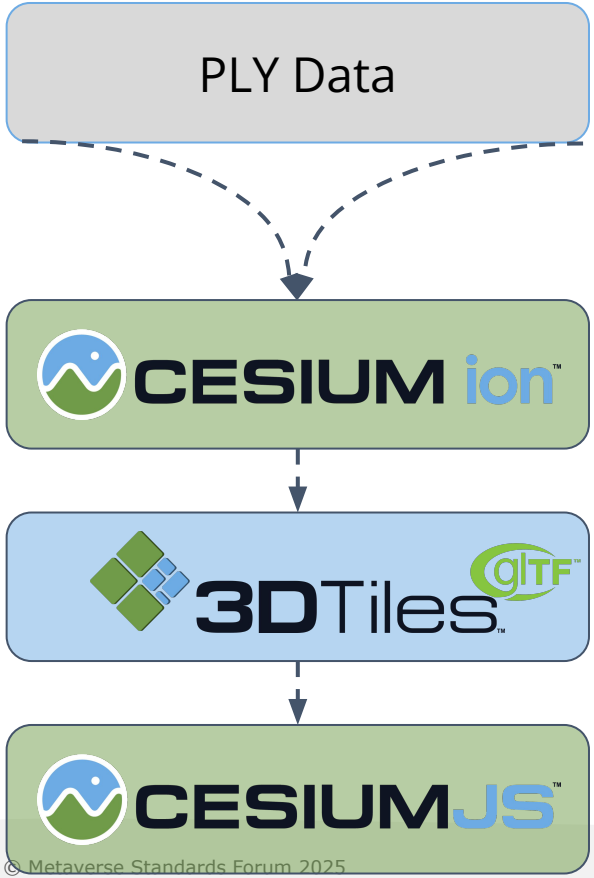
3DTiles glTF™

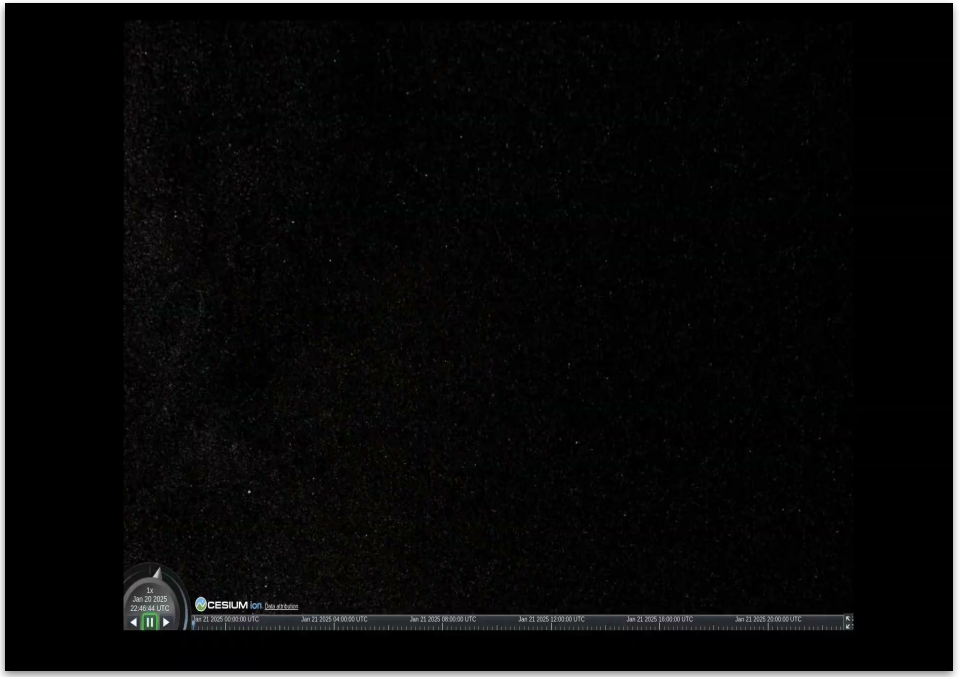
- Collaborate

KHRONOS GROUP Metaverse STANDARDS FORUM™



Our Approach





Open Standards

KHR_gaussian_splatting

```
"meshes": [{
  "primitives": [{
    "mode": 0,
    "attributes": {
      "POSITION" : 0,
      "COLOR_0"  : 1,
      "_ROTATION": 2,
      "_SCALE"   : 3,

    },
  "extensions": {"KHR_gaussian_splatting":{}}
  }]
}]
```

Community Driven

KHRONOS GROUP

CESIUM

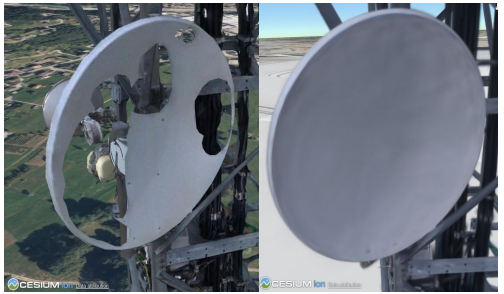
glTF™

Metaverse STANDARDS FORUM™

https://github.com/KhronosGroup/glTF/issues/2454

Use Cases in Geospatial

- AEC
- Digital Twins
- Enhanced GIS Visualization
- Historical Site Preservation
- Environmental Analysis
- Disaster Assessment



Detail Preservation

HEXAGON

empowering an autonomous, sustainable future

Gaussian Splatting in Hexagon

Jan 22nd, 2025

Ladislav Horký, CTO @ Melown Technologies, Hexagon

The digital reality feedback loop

Hexagon's technology enable a digital reality feedback loop – creating freedom of insight so you can be proactive, preventative and event-predictive

Reality Capture

Digital capture of the physical world

Design & Simulation

Design and replication of real-world scenarios

Autonomous Technologies

Automation of any task, workflow, machine or decision – enabling action without human intervention

Positioning

Location, tracking, navigation and/or control of anything, anywhere

Location Intelligence

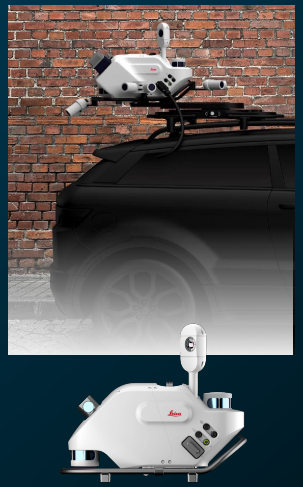
Active, geo-referenced intelligence of real-world situations

HEXAGON

Reality capture from the sky down to your living room

Sensors & workflows for all levels of reality capture

Airborne Mapping
HxGN Content
Program



Mobile
Mapping

High-End
Scanning

BLK:
Reality-Capture
for Everyone

HEXAGON

HxDR
DIGITAL REALITY

A core Hexagon platform for building digital reality solutions

POWERED BY HXDR

SaaS

Reality Cloud Studio
powered by HxDR

LocLab Cloud
powered by HxDR

HxGN Content Shop

Let your work flow through the cloud.
HxGN GeoCloud

Your Application

USER MANAGEMENT

AUTOMATED PROCESSING

COLLABORATION

STORAGE

DATA STREAMING

INTEGRATIONS

Hexagon Technologies / SDKs / Algorithms / Geospatial Content

External Technologies

PaaS

CONNECT

HEXAGON

Vanilla GS, a mature visualization for localized scenes

Best of both mesh and point cloud

but ...

… 3DGS? 2DGS? GSTex? PBR?

Is there a clear path forward? Format needs to be flexible

but also ...

… Streaming, LODs, geospatial, tree of trees

More infrastructure needed than just a "fancy point cloud"

The Format

Summary

- Should
  - **Streamed** – implicit tiling
  - **Georeferenced**
  - **LODs** – effectively separate GS datasets?
  - Tree of trees – improve overall logistics
  - Flexible GS params support future(?) - GS flavours
  - Minimize originality - Expand existing formats(s)
  - Reference FOSS renderer
  - **Extension of OGC 3DTiles/GLTF as a natural candidate**

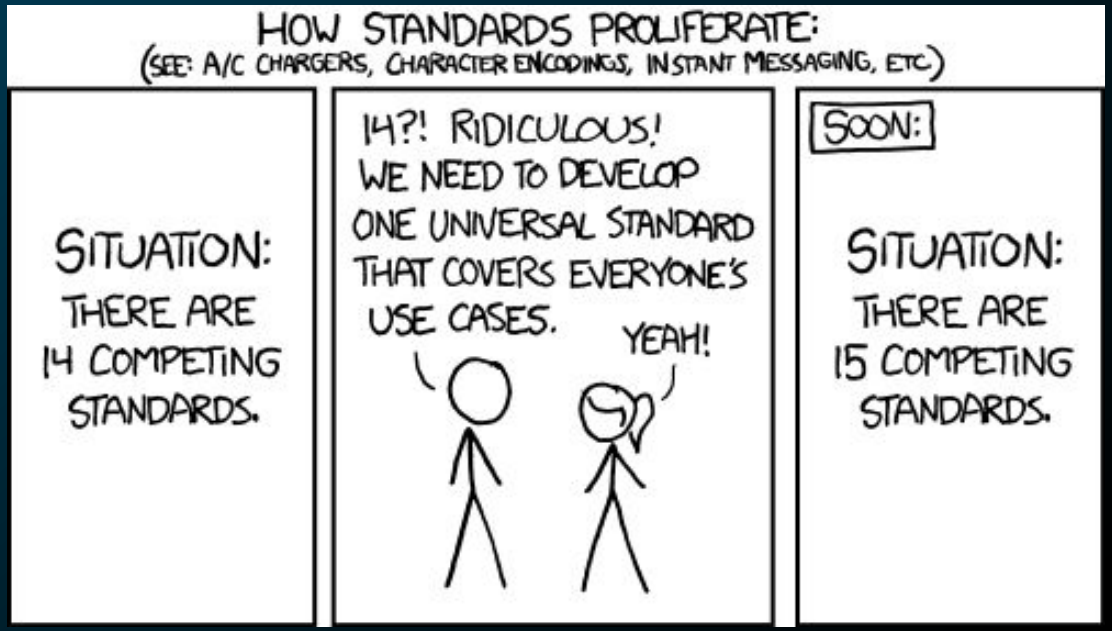
Thank you.

HEXAGON
empowering an autonomous future

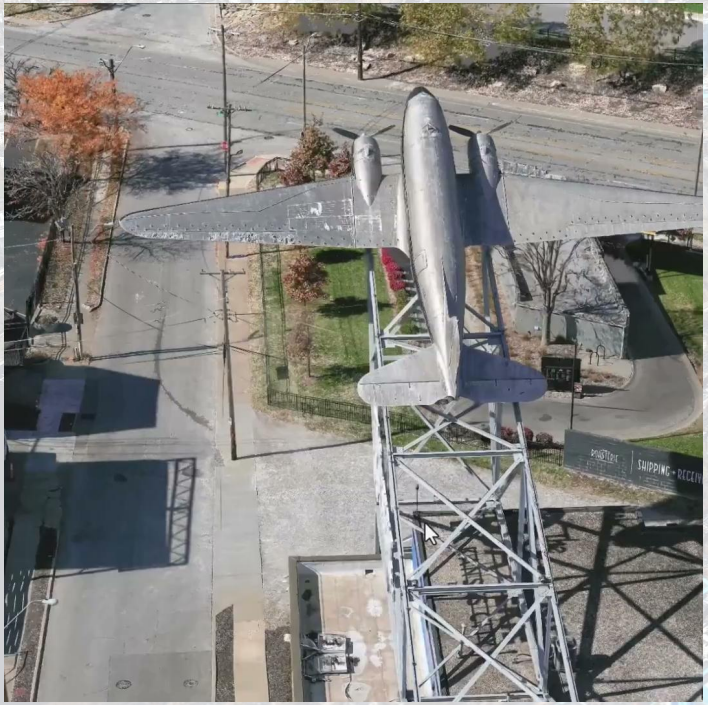
The Format

Summary

- Should NOT (standardize early-ish)

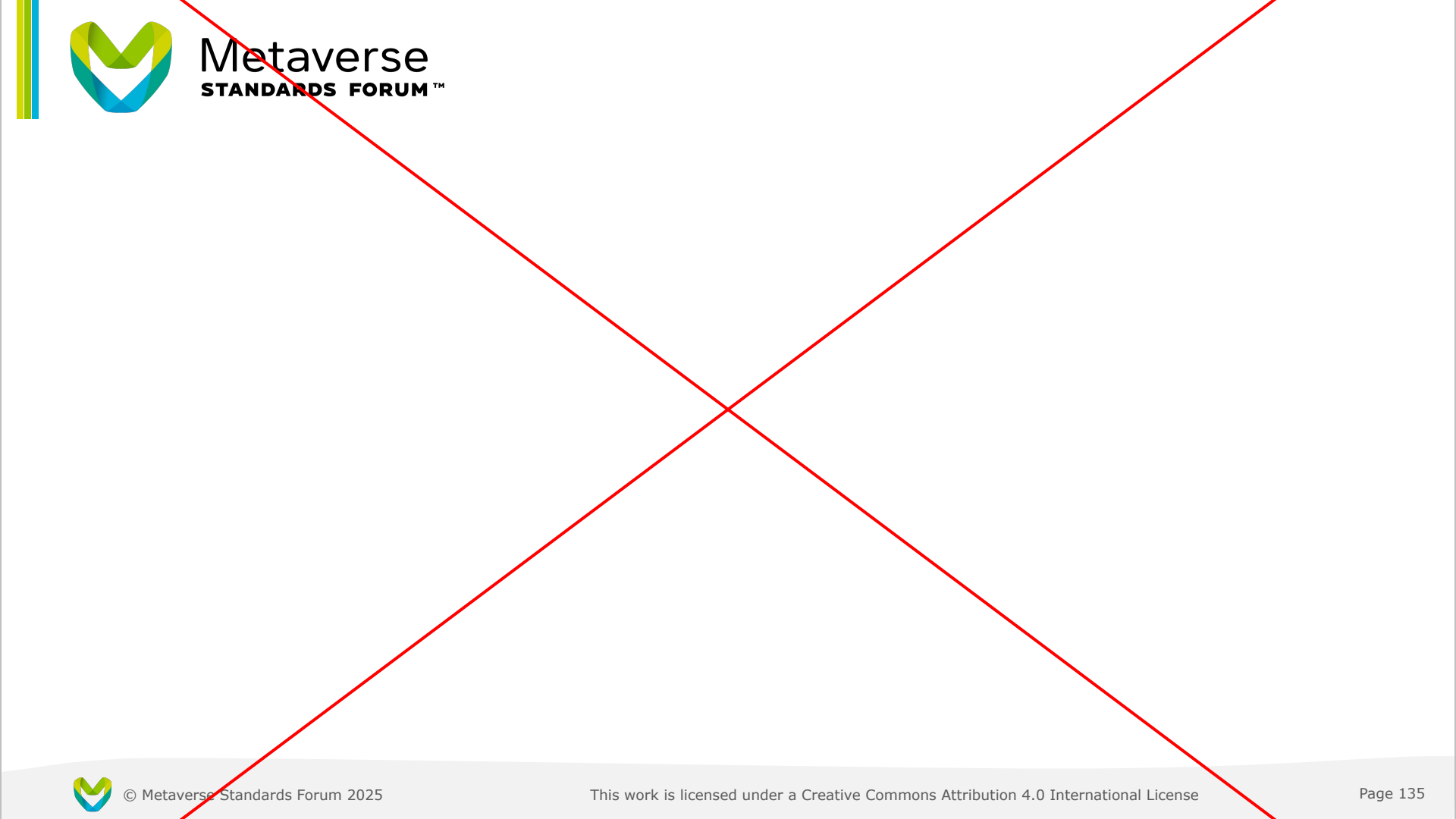


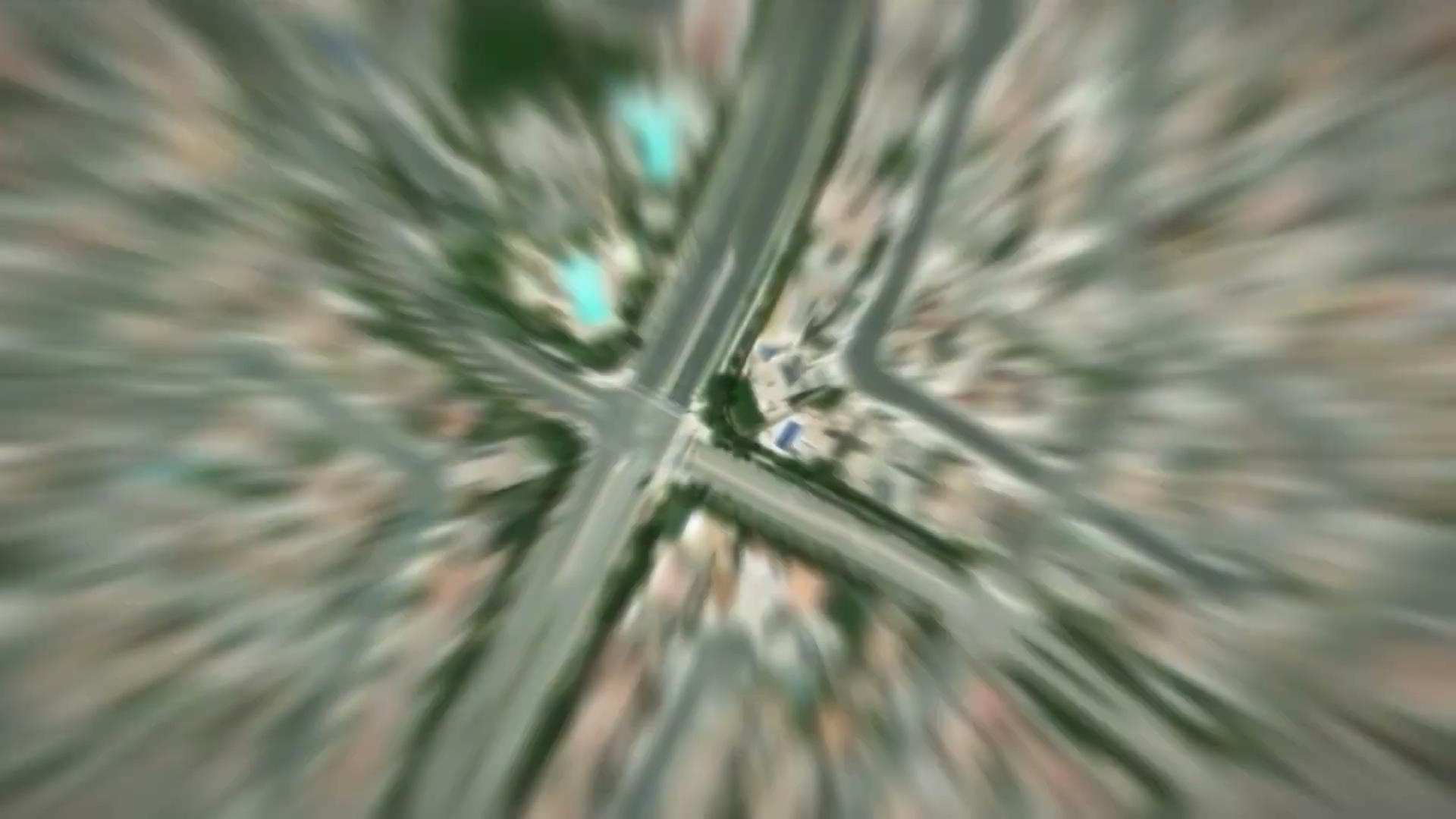
Gaussian Splatting, Open Standards & Digital Twins

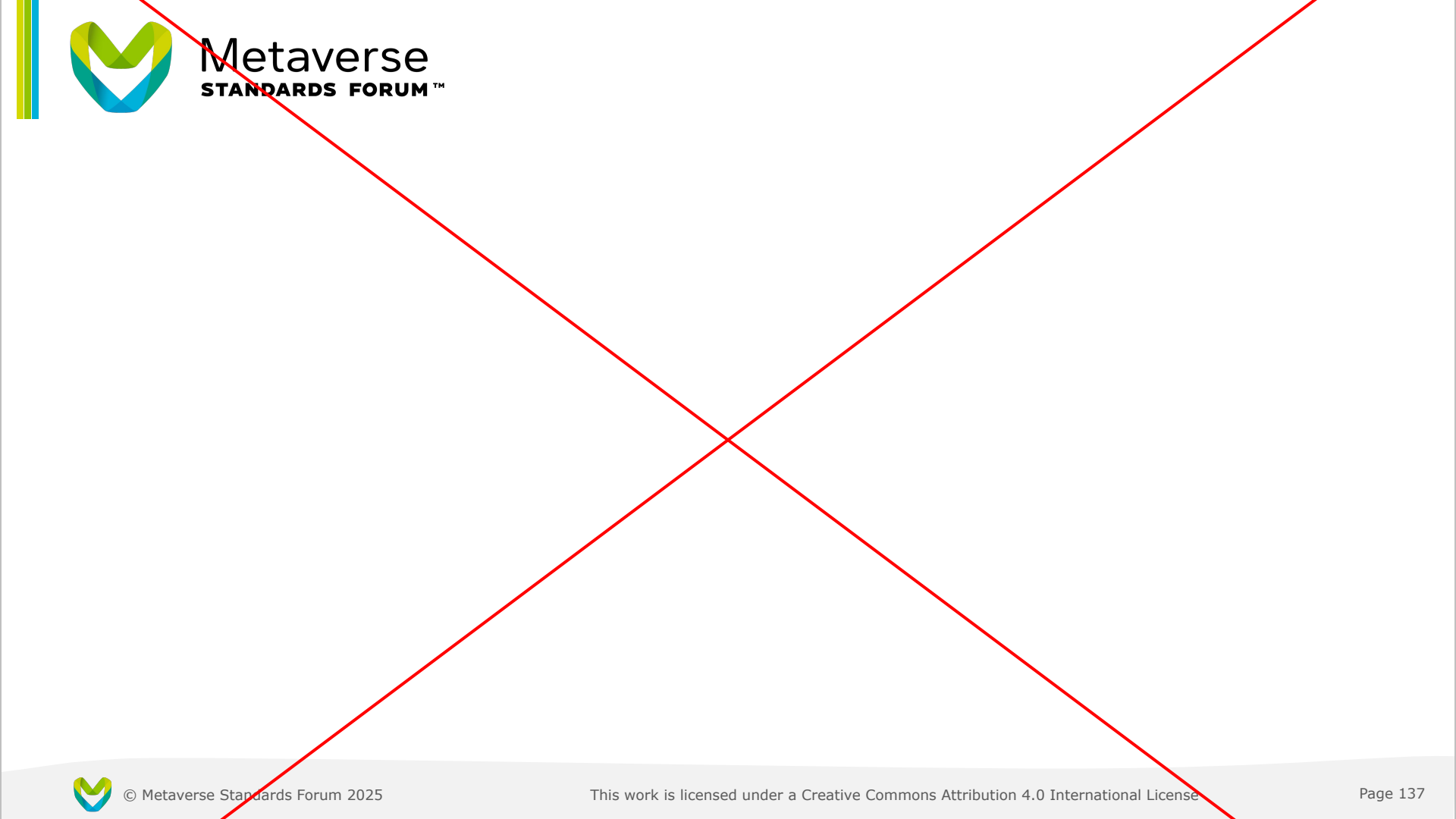


Konrad Wenzel
Director, R&D Center Stuttgart
Esri

Jean-Philippe Pons
Sr. Principal Software Development Engineer
Esri







Digital Twins

- **Virtual representations of the real world**
  - Connecting Enterprise IT systems
  - Leveraging the power of *Open Standards*

Digital Twins

- **Virtual representations of the real world**
  - Connecting Enterprise IT systems
  - Leveraging the power of *Open Standards*

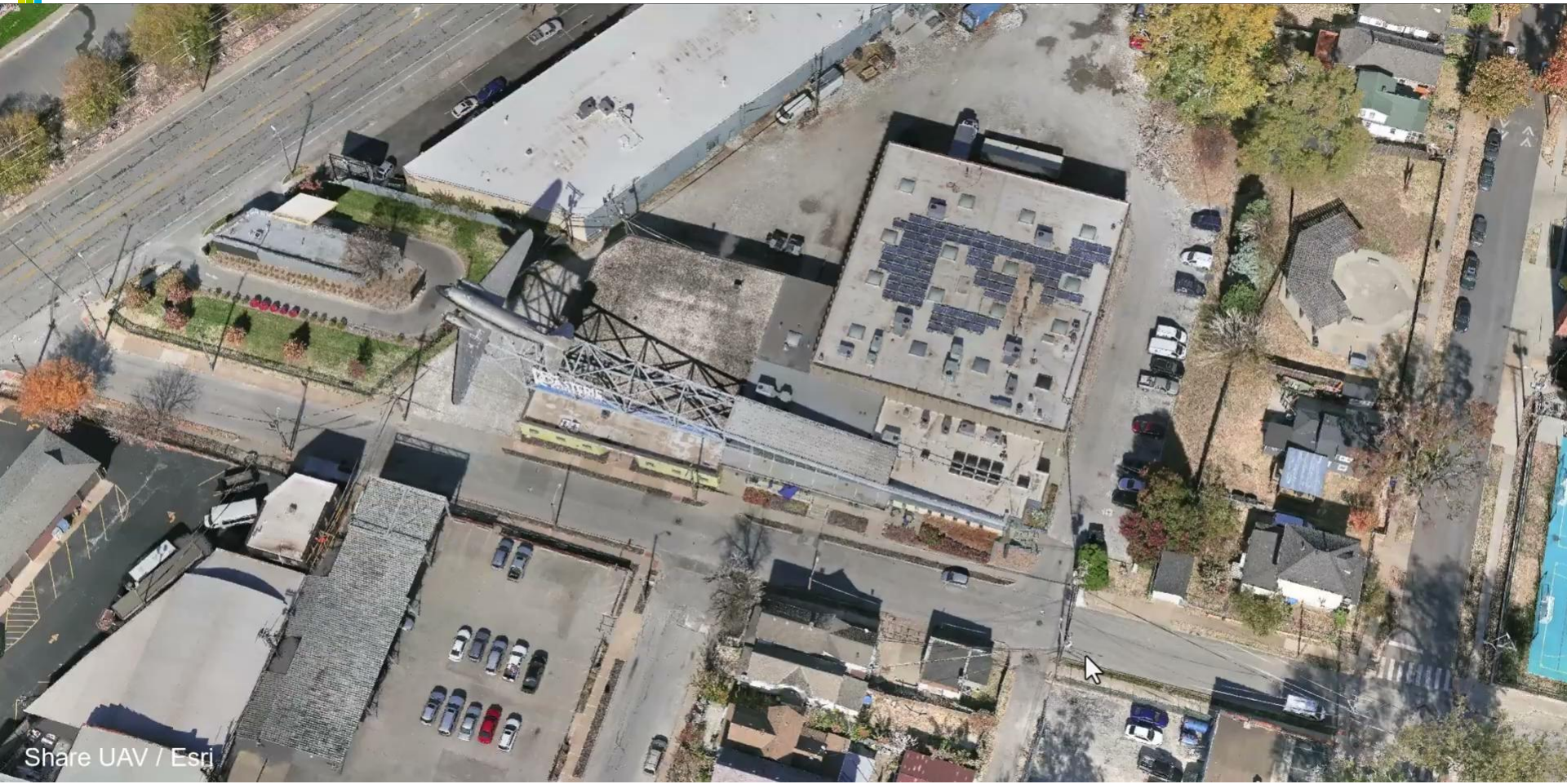
- **Reality Mapping**
  - Foundational content for Digital Twins
  - Enabling continuous monitoring & automated insights
  - Our work: *Reality Engine - survey grade & scalable*
  - *Open Standards*: driving streaming today
    e.g. the power OGC i3s & 3D tiles > foundation for GS

Personal and technical thoughts

- **Looking back**
  - Same story as for reality meshes?

Personal and technical thoughts

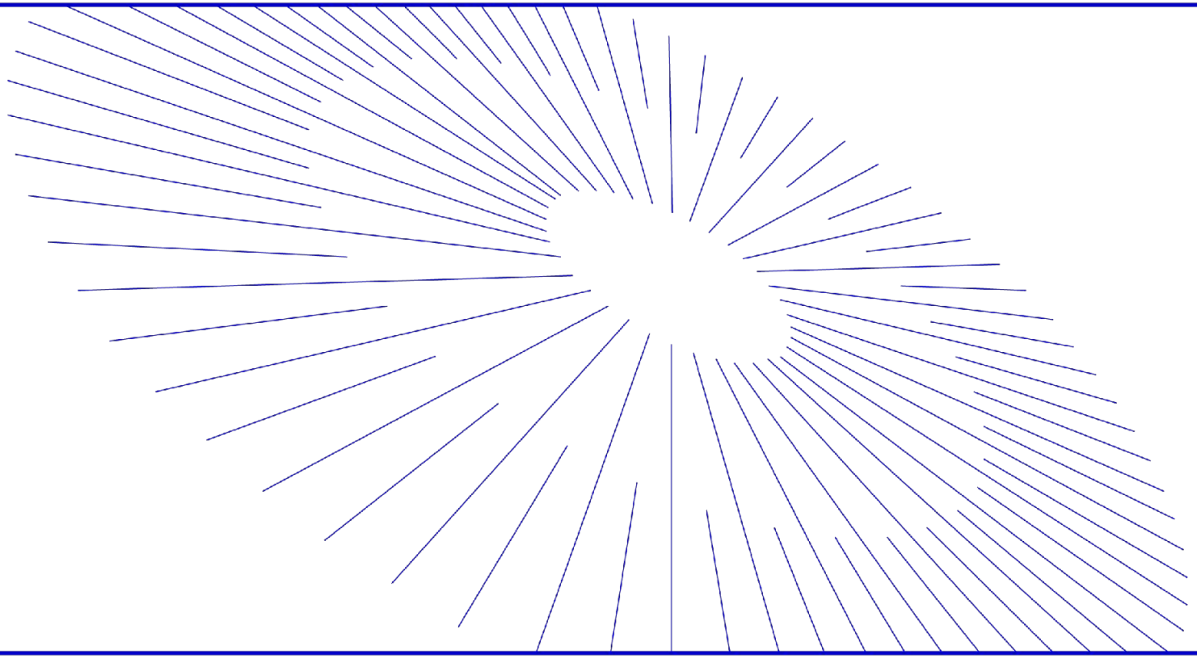
- **Looking back**
  - Same story as for reality meshes?
- **Value beyond realism: Optimization readiness**
  - AI-ready tensor form
  - Perfect fit for photogrammetry



Personal and technical thoughts

- **Looking back**
  - Same story as for reality meshes?
- **Value beyond realism: Optimization readiness**
  - AI-ready tensor form
  - Perfect fit for photogrammetry
- **Know-how in photogrammetry still applies**
  - Fewer artefacts through regularization
  - Reusable engineering aspects
- **Standardization: Yes please!**
  - Learn from first version and implementations
  - Rasterization matters

Gaussian Splatting for Smarter Construction?



EARTHBRAIN

Introduction

Name: Talha Khalid

Experience:

- April 2014-March 2018【Komatsu】
  - ⇨ Production Control & Supply Chain Management

- April 2018-June 2021
  - ⇨ Senior Manager【LANDLOG】
- July 2021～Current
  - ⇨ Global Dev. Manager【EARTHBRAIN】

DX

EARTHBRAIN- Who We Are

February, 2015.
Komatsu
Start Smart Construction
safe and productive
Create a smart, clean future

October,
Birth of Landlog
in and out of the construction industry
open platform

July, 2021.
EARTHBRAIN
Birth

2016 2018 2020

Vision

Create the future of construction worksite by optimizing productivity, safety and sustainability through **digitalized construction processes**

Mission

Initiate a global revolution in productivity, safety, and sustainability of **civil engineering construction worksites** with digital technology

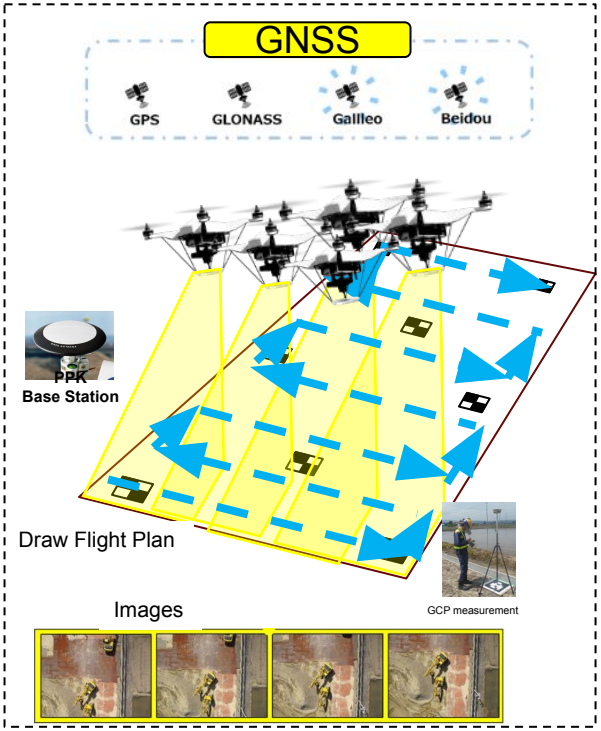
Smart Construction aim for further advancement by 4 companies in cooperation

Company name	Business descriptions	
Komatsu Ltd.	Const. machinery manufacturer	Know-how in DX Smart Construction
NTT Communications Corporation	Telecom	Network/cloud infra., data center image analysis, AI, etc.
Sony Semiconductor Solutions Corporation	World #1 image sensor manufacturer	Sensing technology for field visualization
Nomura Research Institute, Ltd.	Business IT solution provider	Digital solutions/services for business transformation

Smart Construction Apps

Objective	Maximizing Customer ValueLevel	Target Items
Create a Global Customer Base	 **Level 1** **ICT Integration of CE** Efficiently move soil for excavation and leveling using 3D technology  **Level 2** **ICT Integration of Job Sites** The progress and performance of equipment, labor, and materials can be understood through data, and the terrain of the construction site is digitized in 3D	Smart Construction 3D Machine Guidance Smart Construction Edge Smart Construction Rover Smart Construction Quick3D Smart Construction Pilot Smart Construction Fleet Smart Construction Whiteboard Smart Construction Dashboard Smart Construction Remote
Deepen SC	 **Level 3** **Visualization of the entire construction process** Connects machinery, labor, and materials involved in the entire construction process and monitors the entire construction process.  **Level 4** **Optimization of construction plan** Review construction plans based on budget and actual results, and create the optimal construction plan through simulations	Smart Construction Design3D Smart Construction Field Smart Construction Office Smart Construction Dashboard Smart Construction Simulation

Digital Twin

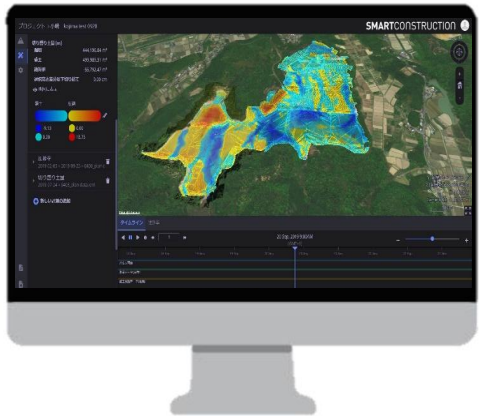


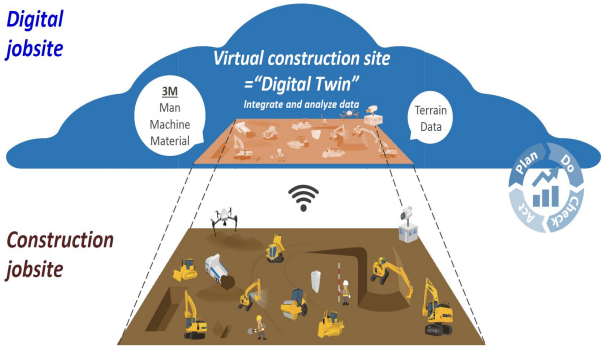
Photogrammetry

3D data

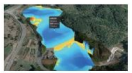
Upload

Smart Construction Dashboard



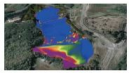


#1 Calculate amount of earth

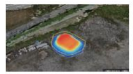


#2 Calculate elevation/gradient

#3 Grasp progress rate

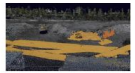


#4 Calculate area

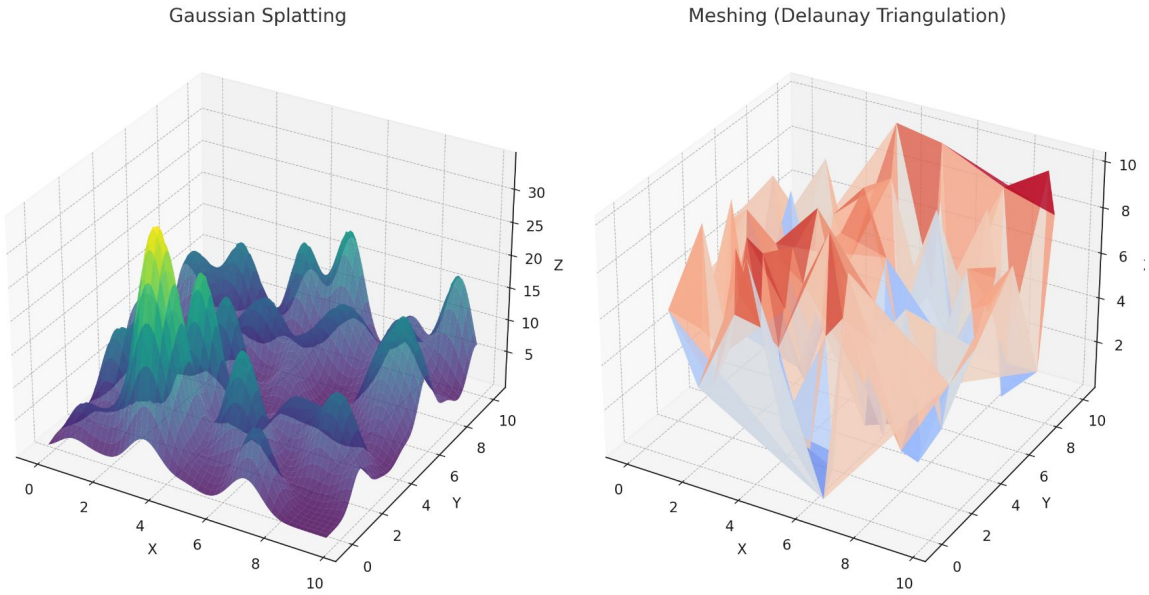


#5 Give an instruction with notes

#6 Sync ICT machine information



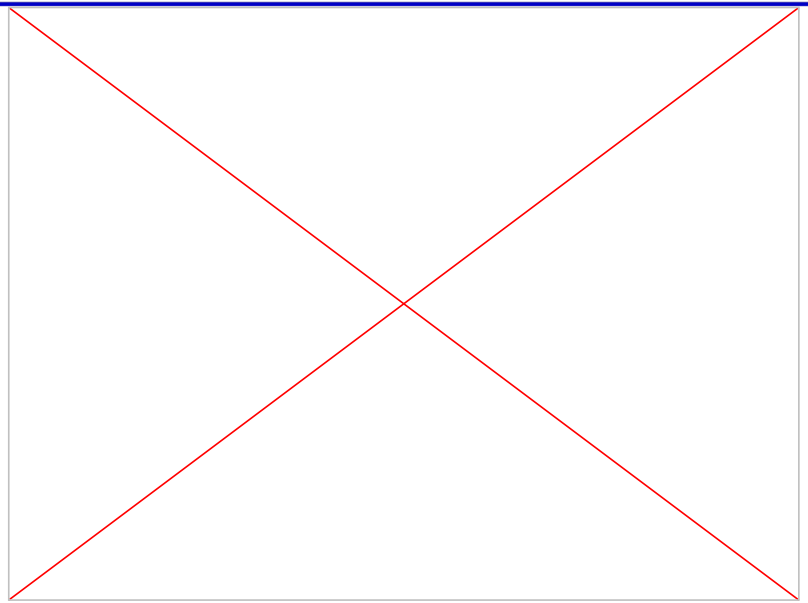
Is Gaussian Splatting better?

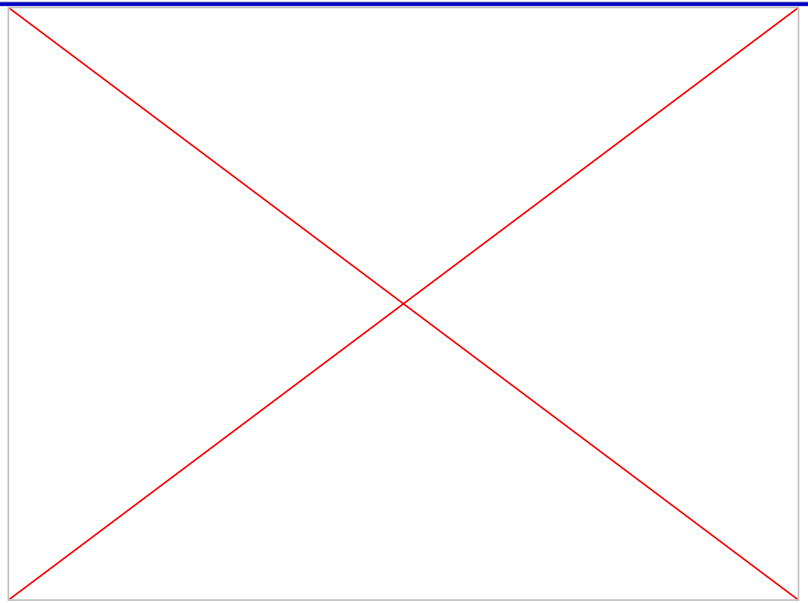


Some opportunities in using Gaussian Splatting

- **Better visualization**
- **Less noise**
- **Less computational complexity**
- **Fever images required**
- **But less precision**

Key Findings and Unlocking Potential Use Cases





Drone data alone makes it difficult to accurately reproduce accurate 3D surface.

However, in smaller sites/areas, partial reproduction may be possible.

Exploring Potential Use Cases:

- **Disaster recovery**: Quick 3D models for earthquakes and landslides.
- **Rapid visualizations**: For presentations or overviews.
- **Final design models**: Where precision isn't critical.

Geospatial Streaming with Gaussian Splats and OGC 3D Tiles

Emeric Beaufays - JDULTRA

JDULTRA

VOLUMA.AI

ROCK GARDEN

Global Q&A and Wrap Up

Thank you to ALL the presenters today!

And thank you to everyone for attending and the great discussion!

Slides and recording will be posted to the Metaverse Standards Forum Video Library
Watch out for an alert email

The event Discord channel will kept open for ongoing community discussion

This session has been hosted by the Metaverse Standards Forum
A neutral forum for Standards Organization and industry cross-domain collaboration
Assisting and encouraging standardization for 3D, XR and the metaverse

All organizations are welcome to join the Forum!
Entry level membership is free!
Paid membership to lead and support Forum activities

https://metaverse-standards.org/

Metaverse
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