GDA Project : 3D Gaussian Splatting

Pierrick Bournez, Amruth Srivathsan ,

Paul Tabbara

Problem: From a Series of Images, Create a 3D reconstructed scene

Application:

Robotics, Virtual Reality…

Prior Works: NeRF

(from the NeRF paper)

History:

- NeRF used Deep Learning

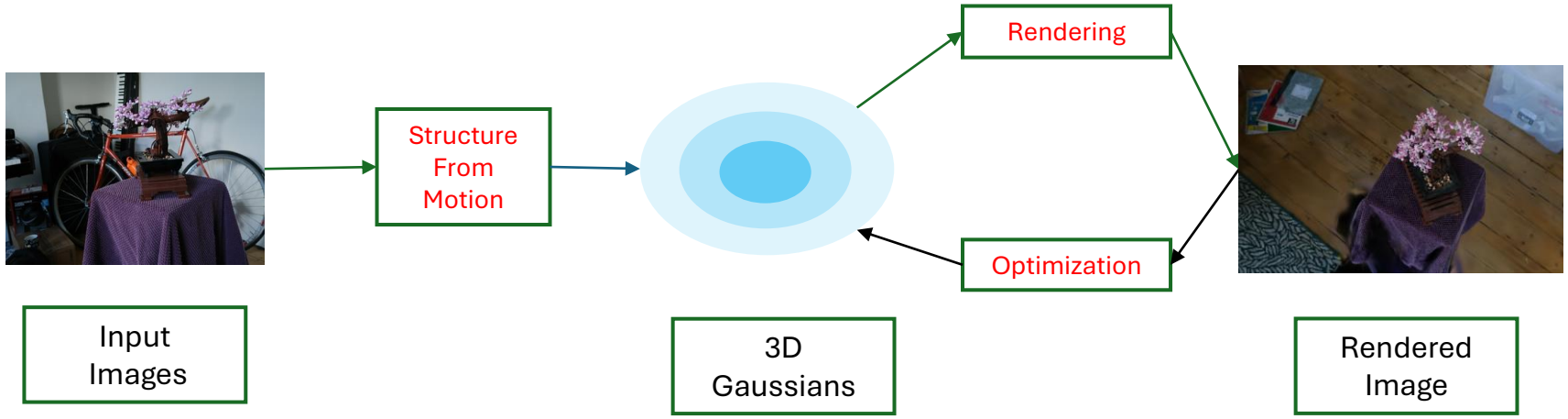
Drawbacks:

- Long Training time
- Slow Inference

NeRF

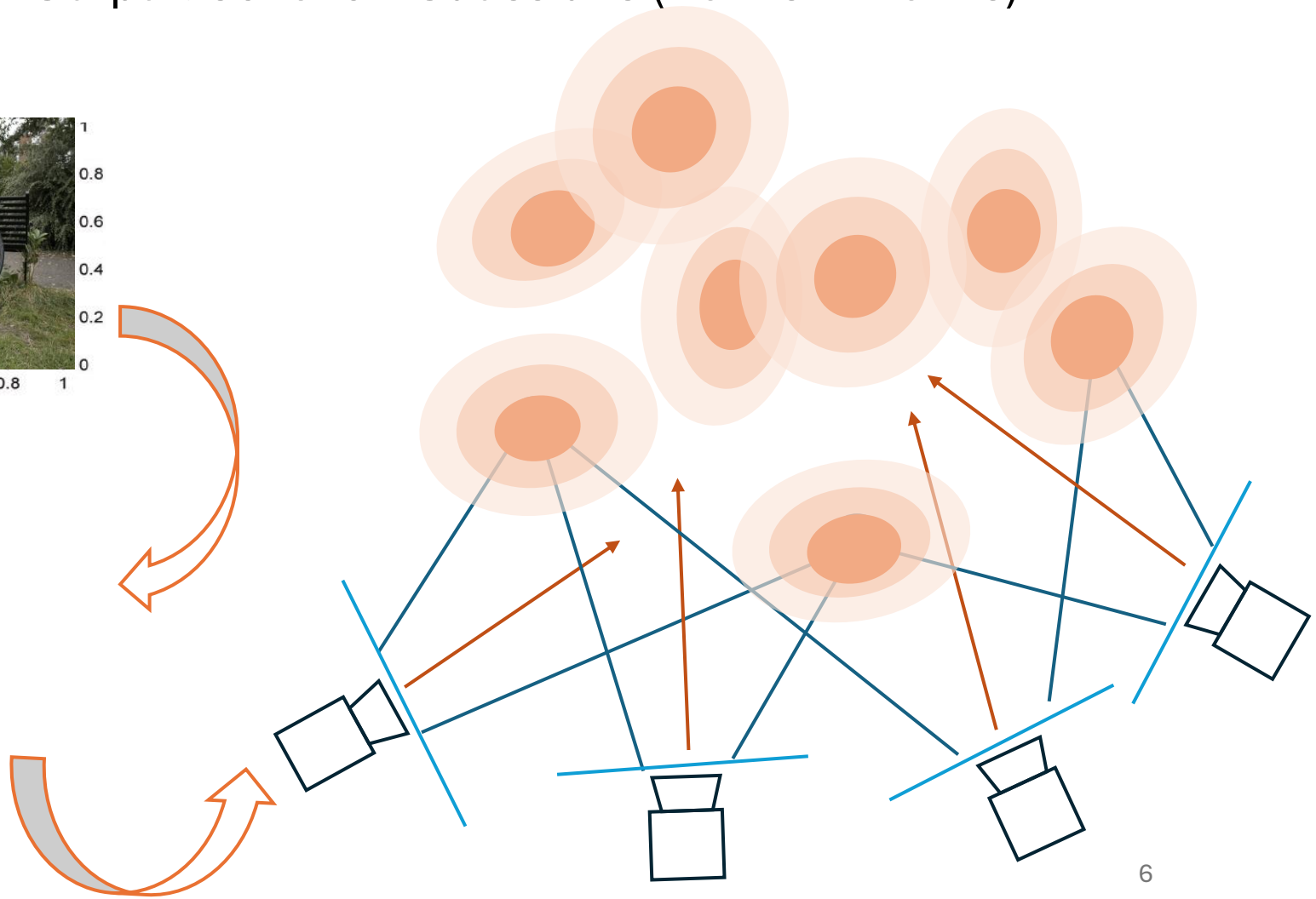
3D Gaussian Splatting

Methodology of Original Paper



Initialization (3D scene from 2D Images)

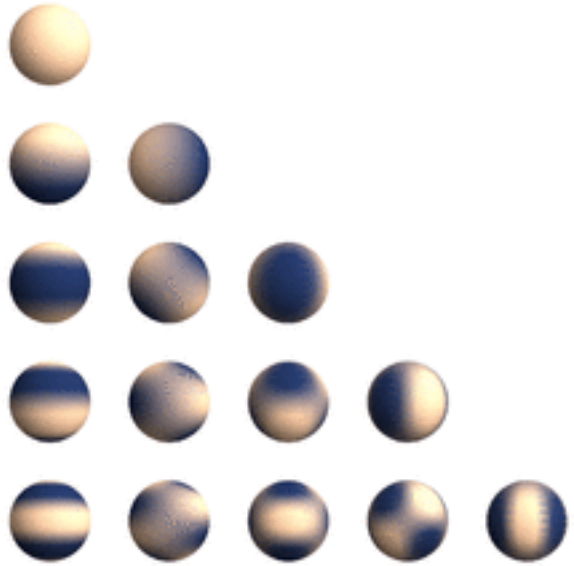
- Input: Set Of Images
- Output: Set of 3D Gaussians (from SfM Points)



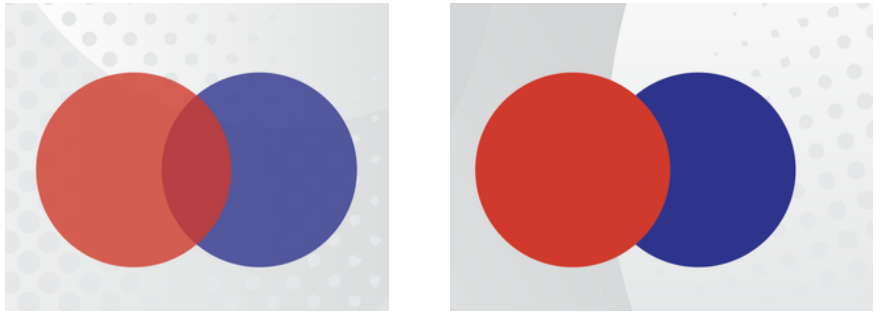
Building Block: 3D Gaussian

- 3D Gaussians Space Parameters:
  - 3D positions
  - Covariance

- Color Parameters:
  - Spherical Harmonics
  - Opacity

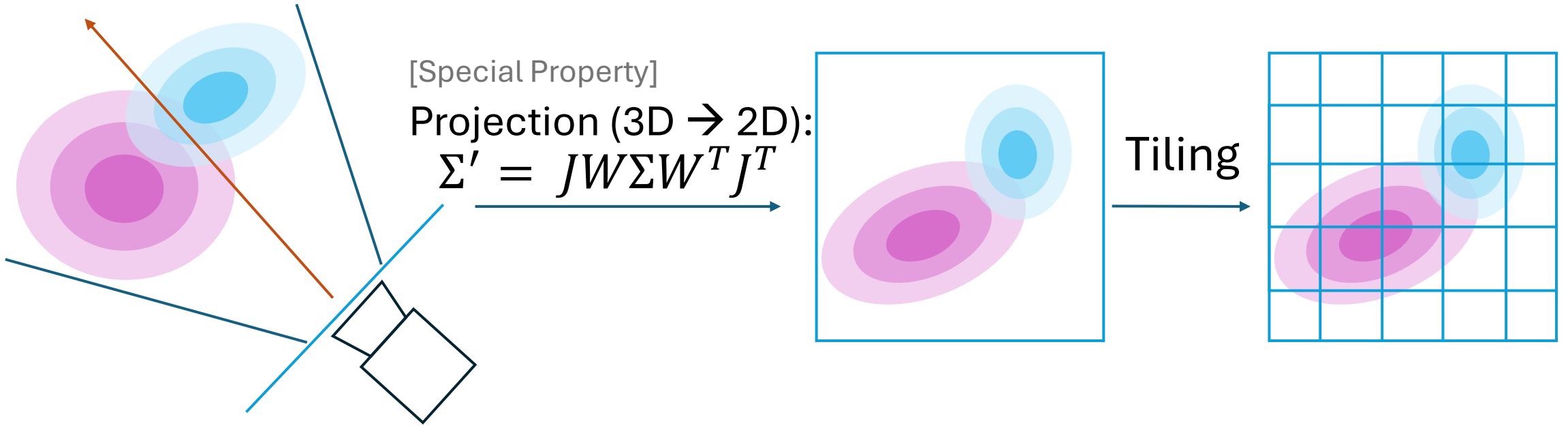


Color Parameters:
Visualization of spherical harmonics behaviours



Color Parameters:
Different opacity value

Rendering


[Special Property]
Projection (3D → 2D):
$\Sigma' = JW\Sigma W^T J^T$
Tiling

Optimization

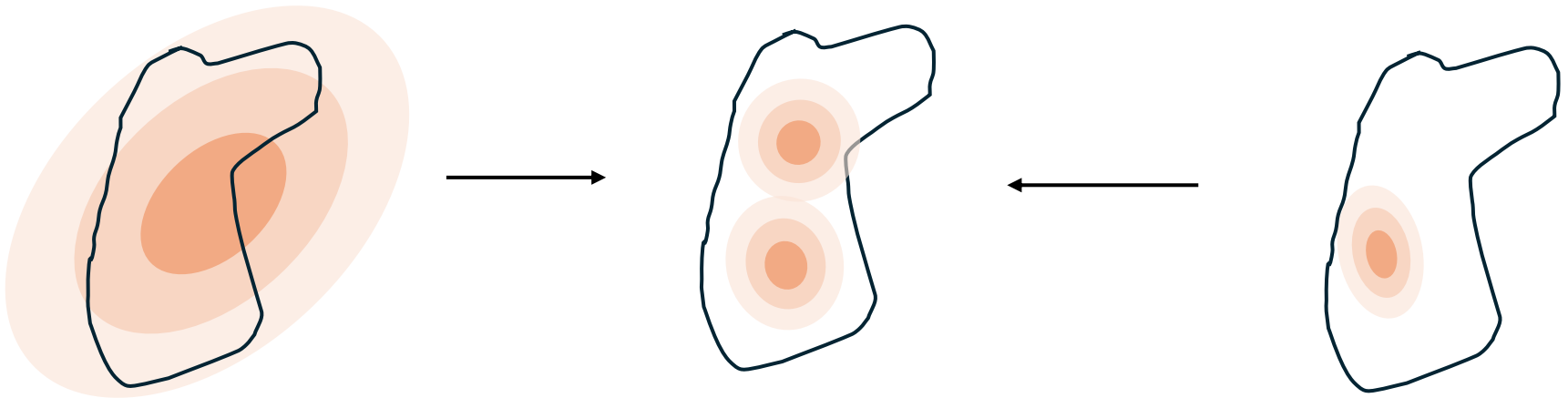
Parameter optimization:

$$L = (1 - \lambda)L_1 + \lambda L_{\{D-SSIM\}} \longrightarrow \alpha, \mu, c, r, s$$

Optimization of number of Gaussians:

Over-reconstruction:

Under-reconstruction:



Limitations and Extensions

Limitation 1 :Holes Due to Missing Camera Views

Extension 1 :
Fixing with "Inpainting"

Input Image

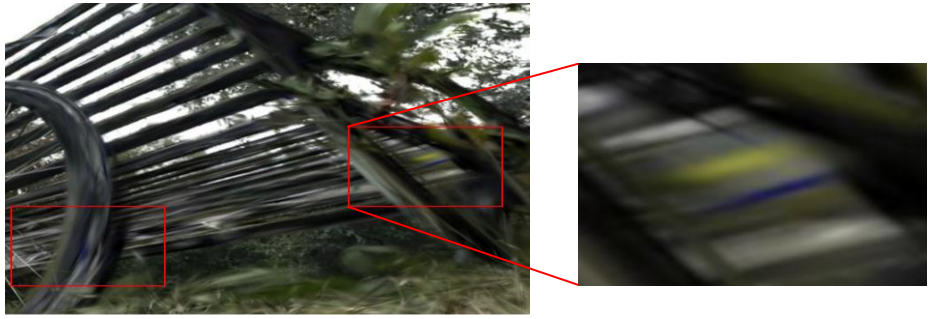
« Fill in the black sections »

(Didn’t give satisfactory result)

« Fill in the missing black sky »
(Improved Result)

Limitation 2 : Color artifacts

Black Specks

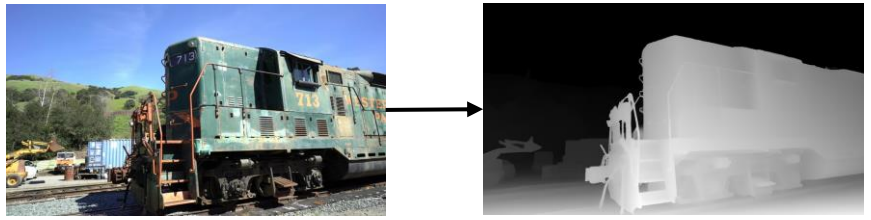


Chromatic aberration

Spherical Harmonics induce blurry artifacts

Extension 2 : Adding Depth Regularization

Using a Depth Estimator, (like DepthAnythingv2)



$$L = (1 - \lambda)L_1 + \lambda L_{\{D-SSIM\}} + L_{\{depth\}}$$

Extension 3 : SFM Comparison CoLMAP/GLOMAP

Dataset	COLMAP (s)	GLOMAP (s)	Speedup (%)
Bicycle	73.74	40.33	82.8%
Bonsai	998.32	232.32	329.7%
Counter	605.83	114.03	431.3%
Flowers	68.48	40.42	69.4%
Garden	555.17	94.10	490.0%
Kitchen	1176.02	173.00	579.8%
Room	727.07	168.50	331.5%
Stump	50.16	18.00	178.7%
Treehill	120.26	48.40	148.5%
Average	**486**	**103**	**293**

GLOMAP is a faster in average SFM solver

Colmap

GLOMAP

Qualitative differences in the output of Gaussian splatting with different solvers

Conclusion

- **3D Gaussian Splatting: Revolutionizing 3D Reconstruction**

A new paper published almost every day on the topic!

- **Our Contributions:**

Identified key limitations and proposed potential extensions.

- **Future Directions:**

Explore mesh reconstruction.

Investigate temporal Gaussian representations.

Limitations	Extensions
Holes due to missing camera views	Fix them with Stable Diffusion
Color artifacts	Depth Regularization
Possible Speed Ups	Compare two SfM algorithm

THE END !