Re-implementation of Seathru NeRF through 3D Gaussian Splatting

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1 Background of Research

Neural Radiance Fields(NeRF) presents a method that achieves state-of-the-art results for synthesizing novel views of complex scenes by optimizing an underlying continuous volumetric scene function using a sparse set of input views.[1] However, as illustrated in Figure1, achieving high visual quality still requires neural networks that are costly to train and render, while recent faster methods inevitably trade off speed for quality.[2] For unbounded and complete scenes (rather than isolated objects) and 1080p resolution rendering, by representing the scene with 3D Gaussians, novel-view synthesis can be rendered in high-quality real-time($\geq$ 100FPS) at 1080p resolution. By leveraging 3D Gaussian Splatting for rendering with existing NeRF models, this project aims to develop a technique that can efficiently generate high-quality dynamic scenes with participating media while maintaining real-time rendering performance.

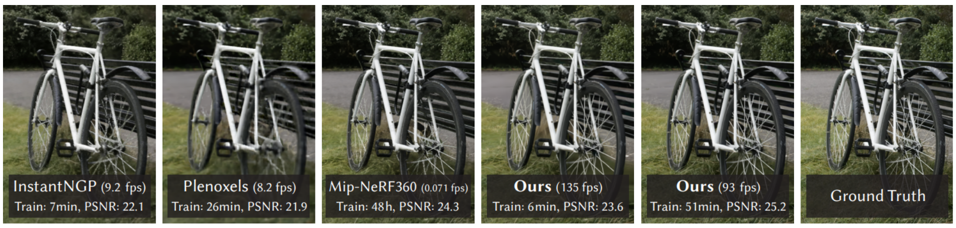

Figure 1: Comparison of various NeRF models on taining and rendering time[2]

2 Proposed Technical Method

The core model that will be reimplemented and extended in this project is the Seathru NeRF, which is capable of generating realistic underwater or foggy scenes where the participating medium influences the appearance of objects.[3] However, unlike the original implementation, the proposed approach will incorporate volume rendering based on 3D Gaussian Splatting. As a result, this project will implement a novel WebGL based Seathru-GS interactive viewer. The new model will also be evaluated against other NeRF models that are generating standard views without the presence of medium.

The performance of the models will be assessed and compared across two key aspects: rendering speed and output quality. The rendering speed will be quantified by measuring the achieved frames per second (FPS) for a fixed output resolution of 1080p. The quality of the rendered scenes will be evaluated using both quantitative metrics, such as Peak Signal-to-Noise Ratio

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(PSNR) and Structural Similarity Index (SSIM), as well as subjective assessments conducted through human visual evaluation.

Figure 2: Neural Radiance Fields in scattering media[3]

3 Expected Results

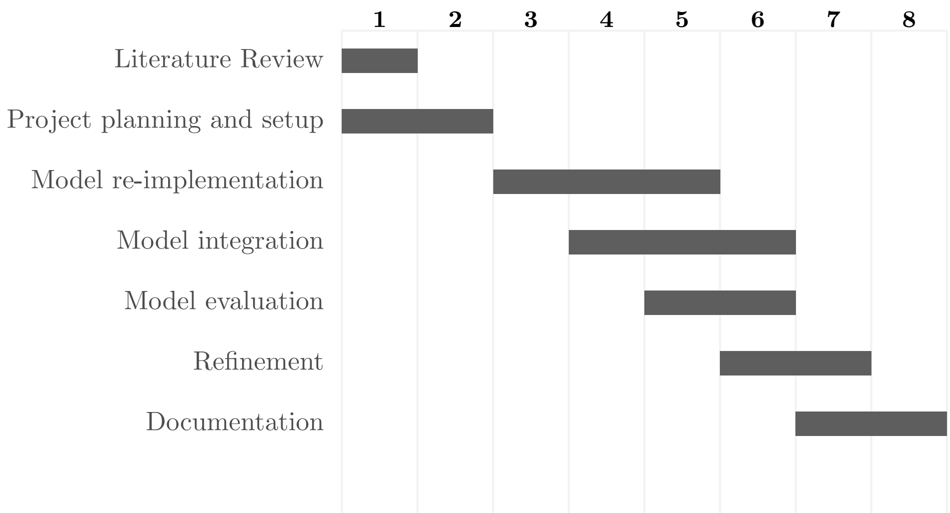
The main deliveries of this project are:

- Implementation of Seathru-GS model
- Development of an online interactive Seathru-GS Viewer based on WebGL

The proposed NeRF with 3D Gaussian Splatting approach is expected to maintain stable rendering speeds for dynamic scenes. Specifically, it should achieve consistently high frame rates during real-time rendering, even in the presence of complex mediums such as water and deliver high-resolution quality when rendering sparsely distributed objects within the scene.

However, this model may struggle to accurately render scenes containing objects that deviate significantly from the assumptions of the 3D Gaussian model like abnormally elongated or extremely irregular shapes. The model may also encounter difficulties when tasked with rendering densely packed arrangements of numerous small objects.

4 Timeline (Week)



References

[1] *NeRF: Representing Scenes as Neural Radiance Fields for View Synthesis*, Ben Mildenhall, Pratul P.Srinivasan, Matthew Tancik, Jonathan T. Barron, Ravi Ramamoorthi, Ren Ng, 2020

[2] *3D Gaussian Splatting for Real-Time Radiance Field Rendering*, Bernhard Kerbl, Georgios Kopanas, Thomas Leimkuhler, GeorgeDrettakis, 2023

[3] *SeaThru-NeRF: Neural Radiance Fields in Scattering Media*, Deborah Levy, Amit Peleg, Naama Pearl, Dan Rosenbaum, Derya Akkaynak, Simon Korman, Tali Treibitz