CrossGaussian: Enhancing Remote Collaboration through 3D Gaussian Splatting and Real-time 360° Streaming

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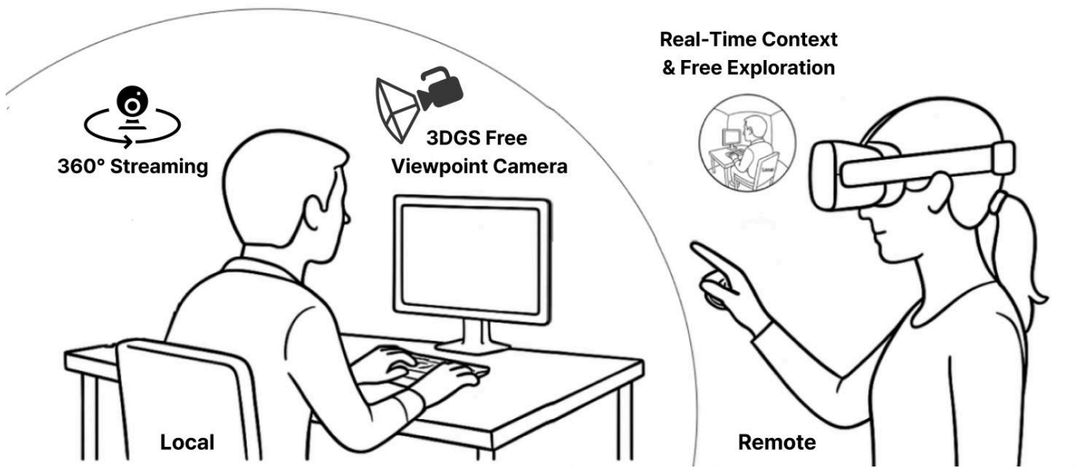
Abstract

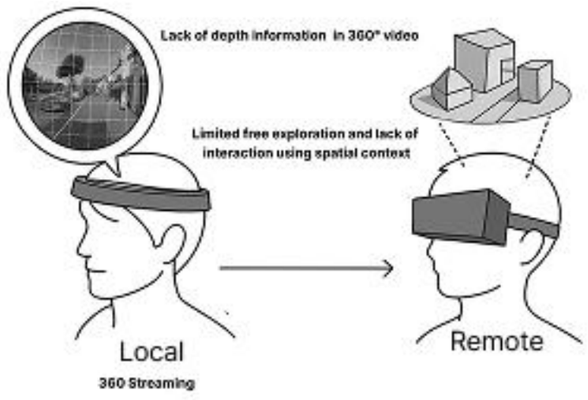


Remote users often face significant challenges in remote collaboration systems when joining virtual scenes primarily reconstructed from a local user's environment. They are disadvantaged by the information asymmetry inherent in a shared virtual environment compared to local users. These limitations also make it difficult for remote users to directly interact within the spatial context.

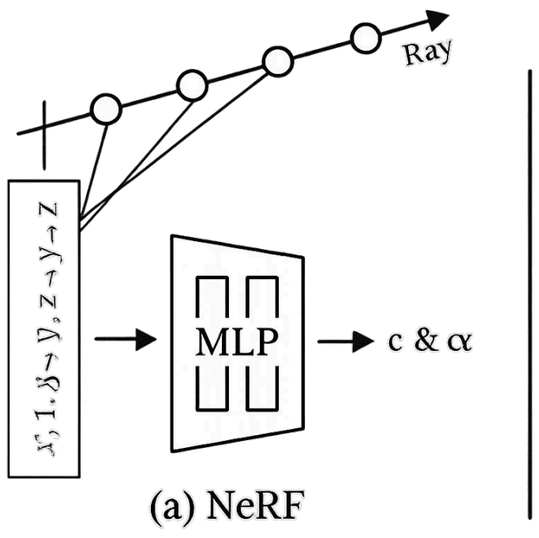
We present CrossGaussian, a VR collaboration system designed to address these limitations by providing remote users with a comprehensive 3D interactive view of the shared environment, created using 3D Gaussian Splatting (3DGS).

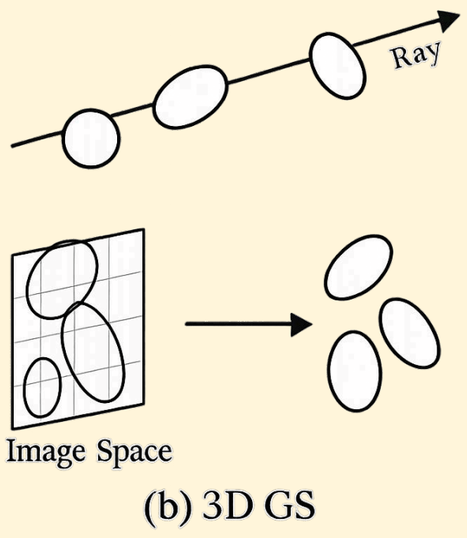
Introduction

Although 360° video streaming provides a wide field of view in remote environments, video-based scenes lack depth information and limit viewpoint control. While free engagement is critical for effective remote collaboration, expanding the coverage of shared environments remains challenging



Recent advances in camera-based 3D reconstruction—such as photogrammetry and NeRF—have demonstrated potential for realistic scene modeling. However, photogrammetry yields surface-centric meshes with limited responsiveness, and NeRF-based methods require high computational cost, making them impractical for large scale real-time collaboration.





In this study, we focus on emerging methods in dynamic scene modeling enabled by 3D Gaussian Splatting (3DGS), which enables the fast, accurate, and highly responsive capture of large-scale physical environments. We present CrossGaussian, a system that blends real-time 360° video with 3D Gaussian Splatting (3DGS) to enable free-viewpoint exploration and novel viewing interactions in remote environments.

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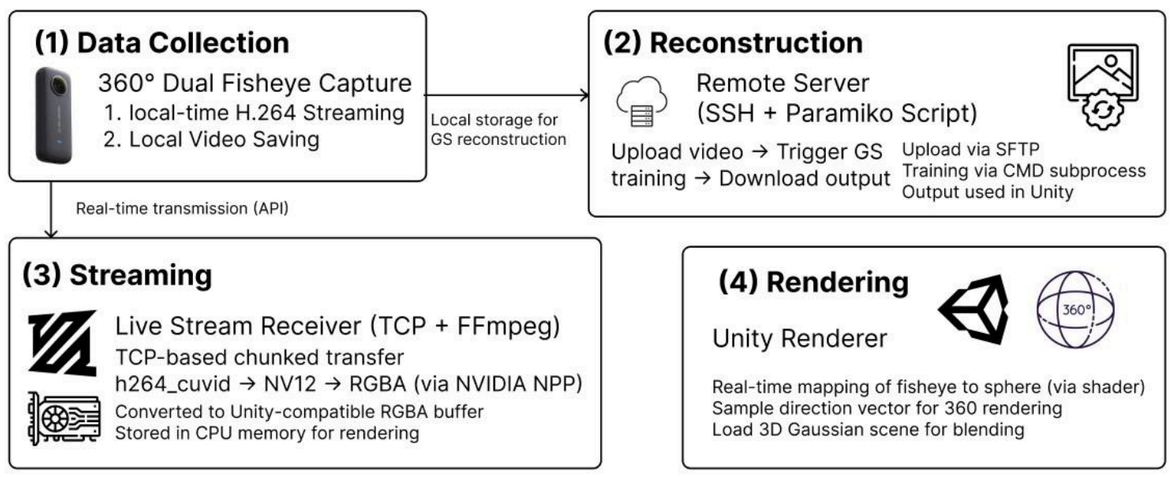
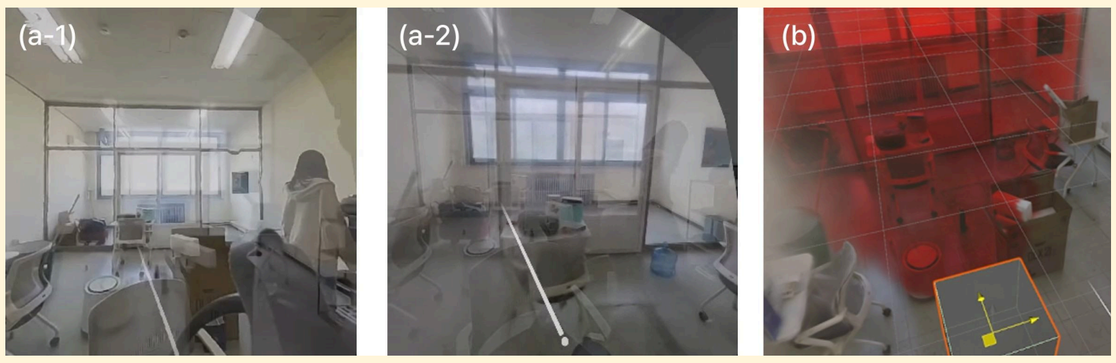
To facilitate the efficient application of 3DGS in VR-based remote collaboration, we propose a fully automated pipeline that integrates preprocessing, remote model training, and rendering. By simply capturing a 360° video, users can initiate a process that runs entirely on remote GPU servers, enabling real-time 360° streaming alongside the generation of high-fidelity 3DGS scenes



The system has data collection, reconstruction, streaming, and rendering parts to construct remote environments

Design & Implementation

Blending of Overlapping Scenes: To reduce motion sickness from scene transitions, we overlay 3DGS with 360° video in VR using transparency and color scaling. This allows users to perceive real-time context while exploring freely, easing cognitive load. Users can also adjust blending for a balance between realism and interactivity.



Occlusion-Aware Exploration: To overcome occlusion limits of 360° video, we use 3DGS-based view-dependent visibility. The system detects and highlights occluded areas and supports see-through rendering via depth and alpha blending. Unlike mesh-based photogrammetry, 3DGS allows intuitive, semi-transparent exploration without complex viewpoint control.

Perceptual Evaluation

We studied how reconstruction delays affect user perception, as prior work overlooked this. Results (N=18) show that delays ≥10s significantly reduce perceived manipulability and trust, making objects feel less real and less interactive.

Conclusion

CrossGaussian is the first to integrate a room-scale 3DGS reconstruction with 360° streaming, enabling view-dependent and postprocessable scene representations for remote collaboration beyond object-scale approaches