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NeRF and Niagara Particles System: Transforming classical music composition into interactive music VR experience

Anna Shvets
University of Nottingham
Computer Science Building, Wollaton
Rd, Lenton, Nottingham NG8 1BB, UK
anna.shvets@nottingham.ac.uk

Generative AI has brought the need to redefine the forms of creative expression. The possibilities of AI-driven visual content creation allow contemporary composers to extend their creative abilities and become creators of audio-visual experiences. The application of interactivity, easily achievable in VR environments, further enhances the degree of user immersion, enabling the implementation of a primary music composition idea through visual representation and interaction design. This article presents a new stage in the development of interactive volumetric VR music composition, relying on neural radiance fields (NeRF) and Gaussian Splatting (GS) to build an interactive music VR experience that amplifies the ideological message of an existing classical music composition. This is accomplished by coupling a 3D GS representation with the Niagara particle system. To our knowledge, this is the first attempt to use NeRF and GS in the context of an interactive music VR application.

GenAI. VR. Music XR. NeRF. Gaussian Splatting. Volumetric music composition.

1. INTRODUCTION

The fast development of neural radiance fields (NeRF) methods allows for large-scale scene reconstruction through volumetric point-cloud rendering, enabling the generation of camera views that were not initially captured by hardware. With continuous improvements in reconstruction fidelity, such as the application of anti-aliasing techniques in models like MipNeRF360 (Barron et al. 2022), Rip-NeRF (Liu et al. 2024), and ZipNeRF (Barron et al. 2023), along with the acceleration of training speed through Instant-NGP (Müller et al. 2022), Quadrature Fields (Sharma, Rebain & Tagliasacchi 2023) and Frustum Volume Caching (Steiner et al. 2024), and, finally, re-lighting capabilities via diffusion-based methods (Zhao et al. 2024), allows the application of this technology in the artistic contexts, including XR (Taniguchi 2024).

3D Gaussian Splatting (3DGS), which emerged as an alternative to photometry, is a result of radiance field rendering and represents a static Gaussian-splatted volumetric point cloud, where the points are depicted as splats. An essential aspect of its practical use in artistic and gaming contexts is the integration of 3DGS within two major game engines: Unity and Unreal Engine. While the generation of new camera views and Gaussian splats is possible in third-party software like PostShot (jawset.com) or NeRFStudio (github.com/nerfstudio-project), the plugin for Unreal Engine 5 by XVERSE (github.com/xverse-engine/XV3DGS-UEPlugin) integrates this functionality directly within the engine, offering the ability to edit the generated Gaussian splats using a cropping box. Another important distinction of the XVERSE plugin's implementation is its mapping of Gaussian splats to a Niagara particle system, which enables the application of physical forces conditioned by user motion input or audio properties.

On the other hand, the increasing importance of visual input, as a result of media influence (Collins 2022), and the expectation of interactivity in volumetric settings (Yong et al. 2022), call for new forms of music art within the emerging field of Music XR (Turchet, Hamilton & Çamci 2021). The current research contributes to the development of the volumetric music composition – an original award-winning music XR genre proposed in 2023 (Shvets & Darkazanli 2023). The previous phase of research has shown the efficiency of neuromorphic computing application in visual data optimization for carbon print reduction and performance amelioration (Shvets & Trzepizur 2024). Current research steps further, exploring the ways of generative AI use for visual narrative generation, derived from the primary music composition idea.

The interactivity aspect of the volumetric music VR composition in its previous implementations ("Omega" and "Interlace" VR music applications) was highly appreciated by the users during testing sessions at music festival "Soeurs Jumelles" in France during 2023–2024 (Shvets & Trzepizur 2024), which inspires further research of efficient interactive strategies implementation for music XR applications with a current implementation within the "Galaxy of suffering" VR music composition.

2. IDEOLOGICAL CONCEPT

The music of the project is taken from the third movement "Motrona Komorowska" of the symphony "Saga Wiśniowiecka" by Anna Shvets (annashvetscomposer.wordpress.com/2012/03/02/symphony-saga-wisniowiecka). The piece highlights the precarious position of women during wartime, drawing from Ukrainian history and a real female figure who was hanged without trial in the 18th century. The recent massacres of women in Irpin and Bucha have brought this theme to the forefront. This topic is linked on a visual level to the 30-year occupation of the Ukrainian complex of sacred buildings – Kyiv-Pechersk Lavra – by the local branch of the Moscow Patriarchate (Derkach 2023), which supported the Russian invasion of Ukraine.

Thus, the visual composition of "Galaxy of Suffering" is based on a 3D reconstruction of the main buildings of the Kyiv-Pechersk Lavra, symbolically representing the aforementioned religious organization, which falls apart to form a "galaxy of suffering".

3. TECHNICAL STACK AND VISUAL STRATEGY

The NeRF representation was trained on a 4K drone video of the sacral building, taken from YouTube (youtu.be/cZHqyup_rEw). The training was performed using the XVERSE plugin for Unreal Engine 5.4 over 80,000 steps to achieve aesthetically acceptable visual quality in a VR headset. The training took about 1 hour on an NVIDIA GeForce RTX 4070 GPU. The resulting model was then cropped and mapped to a Niagara point cloud representation using the same plugin.

While the XVERSE plugin does not provide functionality for real-time visualization of the retrieved point cloud and generated Gaussian splats during the training phase, the illustrations of the trained 3D Gaussian model of the Kyiv-Pechersk Lavra complex shown in Fig.1–2, were created using PostShot software.

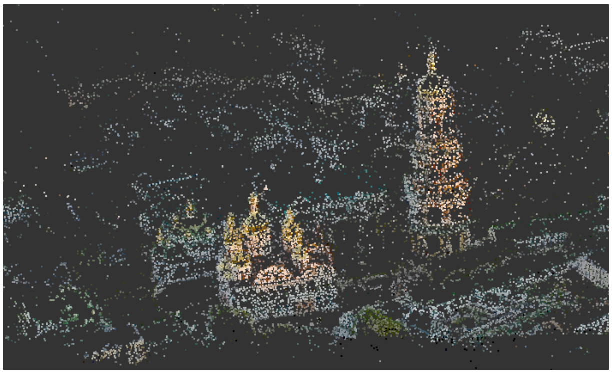

Figure 1: *Point cloud representation of the Kyiv-Pechersk Lavra complex extracted from video using PostShot.*

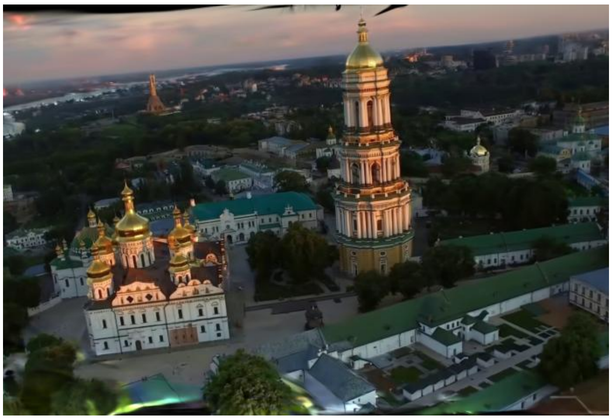

Figure 2: *Gaussian Splatting model after 27K training steps, trained using PostShot.*

The possibility of simulating physical forces within the Niagara particle system allowed for dynamic manipulation of the assigned vortex force direction and power through a Blueprint. The vortex direction followed a unidirectional movement, using a repeated pattern of exchanging movement along the x, y, z, -x, -y, and -z directions until the culmination, where gradual addition of xy and xyz multidirectional movement occurred.

Another important component was the dynamic assignment of colour and its intensity, which visually distinguished the two sections of the music composition: the soprano voice with orchestra in the beginning and the *a cappella* choir at the end. The gradual intensification of the red colour channel from 1 to 10 in the first section helped build the dramatic music culmination, while the intensification of the blue channel from 1 to 5 reflected the galactical dissolution expressed in the second section of the composition.

Finally, the particle size was gradually decreased in the first section to serve two purposes: to express the idea of intensified destruction, amplifying the drama until the music's culmination, while avoiding perceptual saturation of the red colour. Figure 3 shows the effects of red channel intensification and particles size reduction applied simultaneously.

The intensification of the blue channel in the second part of the experience was designed to "cool down" the emotional intensity after the tragic culmination of the first part. The requiem-like choir in the musical component is accompanied by the gathering of particles from the galaxy orbits, symbolizing the spiritual afterlife ascension. Figure 4 shows the gradual intensification of the blue channel with continuous upward movement.

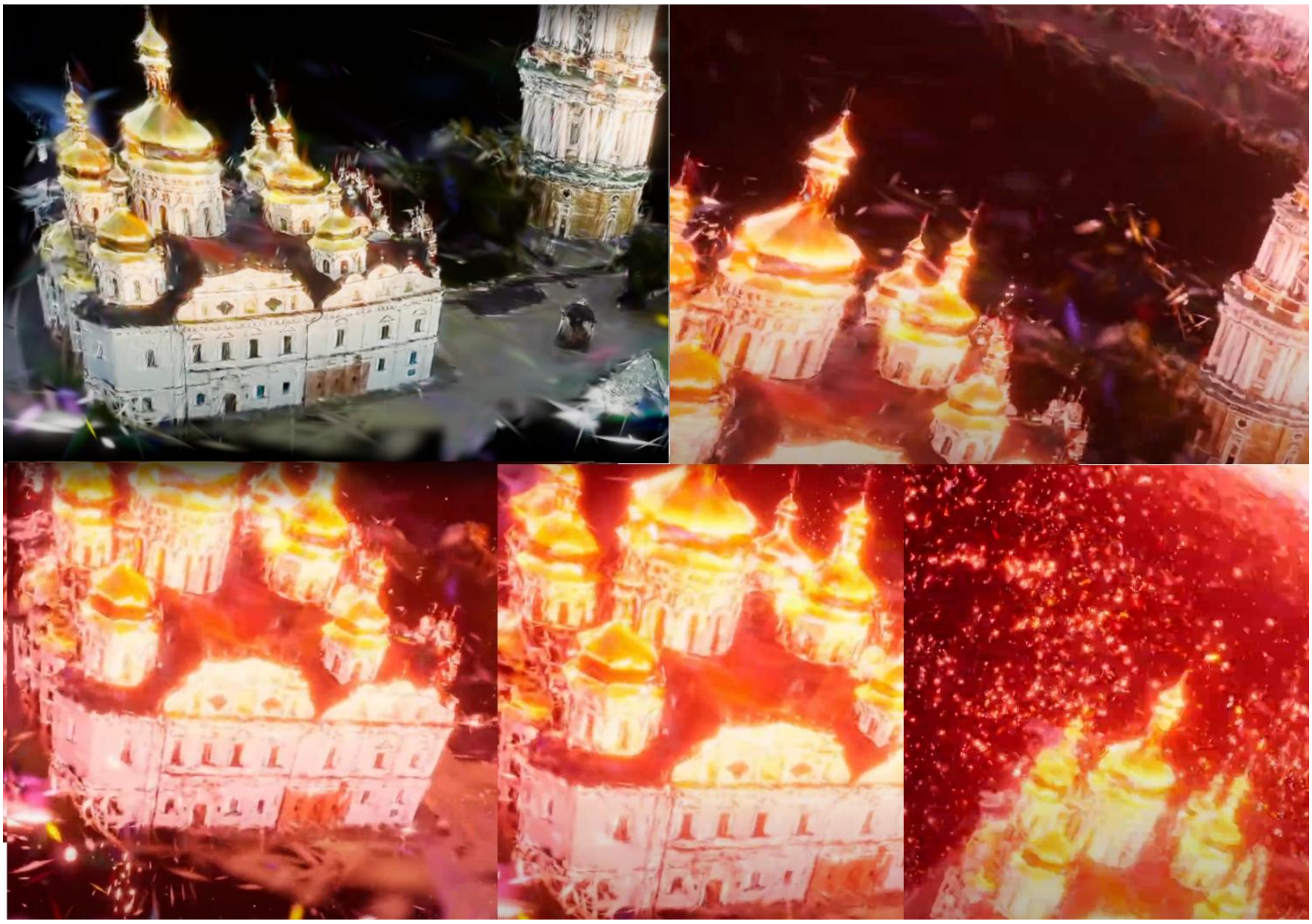

Figure 3: *Red channel intensification and particles size decrease in the first part of the experience at the 1st, 6th, 12th, 18th and 24th bitmap steps, which correspond to the beginning and the end of the first part of the experience.*

Figure 4: *Blue channel intensification the second part of the experience at 1st, 2nd, 4th 8th and 12th bitmap step.*

4. AUDIO INTERACTIVITY

The audio manipulation of the visual component was also divided into two sections: an audio-reactive system for the first section and an interactive music system for the second. This decision was based on the intensity of the visual component, which decreases in the second section, thereby allowing room for interactive exploration of visual elements. Thus, the user's hands become visible only in the second part of the experience.

The first section consists of 24 bitmap steps, each initiating the restart of the Niagara emitter via dynamic manipulation of the loop duration. At each restart, the intensification of dynamic visual parameters occurred, as described in the previous section. The manipulation of the particle movement direction was achieved through a custom scratch module inside the Niagara emitter, which assigned the amplitude of the audio spectrum to the particles' velocity.

The second section consists of 12 bitmap steps, each initiating an intensification of the blue channel. The user interaction with the environment is implemented via pinch gesture event, facilitated by the OpenXR hand tracking framework. The pinch triggers the release of associated chord tones generated by the MetaSound system in Unreal Engine 5, aligned with the bitmap's temporal sequence. The pinch event also releases a stream of particles moving upwards (Figure 5), consistent with the movement direction inherent to the rest of the environmental particles. This allows for the integration of the user's "voice" through embodied audio and visual representation, characterized by a distinct timbre, particle shape, and colour intensity, while maintaining consistency with the overall audio-visual environment.

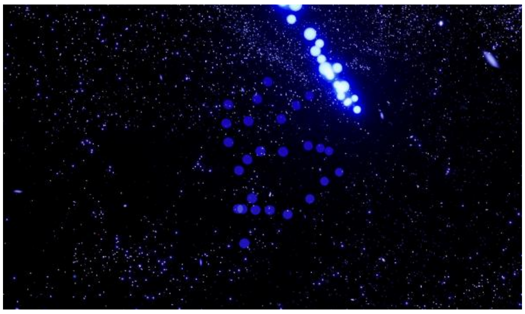

Figure 5: *Sound particles release on pinch gesture.*

5. SHOWCASE

The work was displayed at the Stephen Lawrence Gallery of Art in London from January 17, 2025, to February 13, 2025, as part of the "Reflecting Change" exhibition (greenwichunigalleries.co.uk/reflecting-change). Due to the intensive GPU calculations required for real-time processing, the application is available only as a PCVR experience. As a more feasible display solution, the artwork was presented as a pre-rendered version of the VR experience on a TV screen mounted on the wall. Figure 6 illustrates the installation framework used at the gallery.

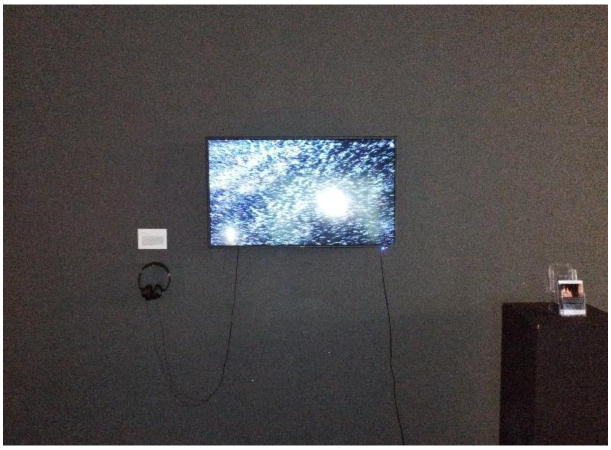

Figure 6: *Form of the artwork display at the gallery.*

6. LIMITATIONS

The need for high-intensity real-time calculations limits the availability of venues with the necessary hardware to publicly display the fully immersive version of the application. Another challenge for scalability is the lack of APIs for automating the alignment of bitmap characteristics with visual representation in VR, necessitating labour-intensive manual event assignment.

A potential solution to these challenges lies in the application of neuromorphic computing strategies and the development of more efficient audio-visual alignment methods. These represent key directions for further research in immersive music composition with AI-generated visuals.

7. CONCLUSIONS

This article presents an interactive music VR application created from an initial classical music composition. The visual component was modelled using NeRF and then transformed into a point cloud representation within the Niagara particle system via the XVERSE plugin for Unreal Engine 5. The bitmap of the music composition, along with its spectral characteristics, influenced the movement patterns of the particles in the first section, implementing a reactive audio system. The second part of the composition introduced the possibility of interacting with the environment through the embodied integration of the user's voice, triggered by a gestural event.

"Galaxy of Suffering" proposes a practical implementation of a new Music XR genre – volumetric music composition – by applying generative AI to fully generate a visual representation of the implicit idea inherent in a classical music piece. The project thus pushes the boundaries of the state of the art in the Music XR domain, exploring the application of generative AI in building interactive, music-driven VR experiences.

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