VR Planica: Gaussian Splatting Workflows for Immersive Storytelling

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Abstract

Gaussian Splatting recently gained a lot of interest for 3D digitization of real-world objects and scenes. Easy-to-use tools are available to professionals, academics, and lay users for 3D asset creation and visualization. However, application in productions such as XR experiences and corresponding workflows have not been studied in detail so far. We present VR Planica, a pioneering experience that applies Gaussian Splatting for immersive storytelling in a journalistic context, where users are immersed into a real environment. We evaluate available tools and present our production workflow. Finally, results of an initial user study are presented.

CCS Concepts

• **Human-centered computing → Interactive systems and tools**; • **Computing methodologies → Mixed / augmented reality**; **Reconstruction**.

Keywords

Gaussian Splatting, Immersive Storytelling, Virtual Reality, 3D Reconstruction, View Synthesis

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1 Introduction

While immersion does not necessarily depend on technology, and any good story may be immersive, even if told by a bonfire, immersive storytelling is nowadays mainly understood as something that is experienced via head mounted displays (HMD) in virtual reality (VR), augmented reality (AR), or mixed reality (MR), which are often summarized under the term eXtended Reality (XR). With maturation of HMDs and associated platforms and pipelines, immersive storytelling becomes increasingly interesting for audiences, creatives, and industries.

Among current XR application areas, gaming is the most important, with training/simulation/education and professional applications (design, assistance, etc.) being well-established too. Artistic productions and documentary content are gaining popularity. Journalism is also an area, where a lot of potential for immersive content is foreseen, as it allows putting audiences into news scenery and making them experience these in novel ways.

This, however, requires capturing real-world scenery and processing it into immersive content, which must be of high quality and authenticity, to be visualized in convincing ways. 360 capture of images and video is well-established in this context, while it only offers limited functionality and quality in terms of visualization and interaction, due to being restricted to rotation (3 degrees of freedom, 3DoF). Photogrammetry is a technology that allows full 3D reconstruction (6 degrees of freedom, 6DoF) from images or video, which is meanwhile well-established to generate 3D models of real-world objects and scenes. Still, the production process is often cumbersome and the results not always satisfying.

Gaussian Splatting (GS) is a technology that recently disrupted the field of 3D reconstruction and 3D content generation [12]. 3D visualizations of real-world objects and scenes based on GS can significantly outperform standard approaches. Applying machine learning with GS as a rich 3D data and rendering format that extends point clouds leads to these improvements. Soon after scientific advances, software platforms became available and even mobile apps, making the technology available to everyone. As such, GS becomes very interesting for immersive storytelling as a tool to 3D digitize real-world content and use it as assets in XR experiences. However, tools, workflows, and pipelines for GS are just emerging, especially related to post-processing, editing, and integration of professional production workflows. Despite the potential, the number of XR experiences or other types of content with GS assets is still limited.

In this paper, we present VR Planica, a pioneering experience applying GS to immersive storytelling in a journalistic context. It is centered around the annual ski jumping event in Planica, Slovenia, and the topic of climate change. We evaluate tools and devise a workflow for production of XR experiences with GS content. We evaluate aspects of implementation and integration. Further, we present results of an initial user study with the experience.

2 Related Work

GS is known in computer graphics as a method for 3D data representation and rendering for decades (see e.g. [24]), which can be regarded as an extension to point clouds adding more sophisticated information. It is also related to volume rendering [23] and radiance field rendering [12]. While GS offers advantages over other approaches, it remained niche compared to other computer graphics representations.

Since 2023, GS receives significant attention in the computer graphics and vision communities [12], as it disrupted the field of 3D reconstruction and view synthesis (similar to Neural Radiance Fields, NeRF, earlier [16]). In combination with machine learning, GS allows 3D visualizations of real-world objects and scenes, captured by multi-view imagery or video, which often outperform classical methods significantly. The seminal paper [12] stimulated a lot of follow-up research, which addressed extensions and improvements, as well as applications. An overview was recently published in [10], and the field remains very active.

GS was not only recognized in the related academic communities, but very soon also inspired potential users, as it allows one to 3D digitize real-world objects and scenes easily and to use them as 3D assets in various applications. Web platforms and mobile apps were released shortly after academic publication, providing GS content creation to everyone, such as Nerfstudio [3], Luma AI [2], Polycam [4], Scaniverse [6], or Postshot [5]. Supersplat [7] is among the first tools for editing GS content. Plugins for the integration of GS content into game engines like Unity have been released such as [17].

Although efficient tools for GS creation and rendering are available, and solutions for editing and integration exist, related pipelines are just maturing, especially related to professional production scenarios. XR experiences or other applications with GS content are rare. With VR Planica we present a pioneering example that showcases and evaluates both, immersive storytelling with GS and corresponding production workflows.

3 Experience Design and Storytelling

VR Planica was designed and developed in the European Horizon project TRANSMIXR [8], which addresses XR and AI technologies for the creative and cultural sector with 22 partner organizations. Journalism is one of the target areas. The partners RTV Slovenija (RTVSLO, national broadcaster) and Agence France-Presse (AFP) as use case partners, and the Lucerne University of Applied Sciences and Arts (HSLU) as technology partner embarked on the endeavor to conceptualize, showcase and evaluate GS for immersive storytelling in journalism.

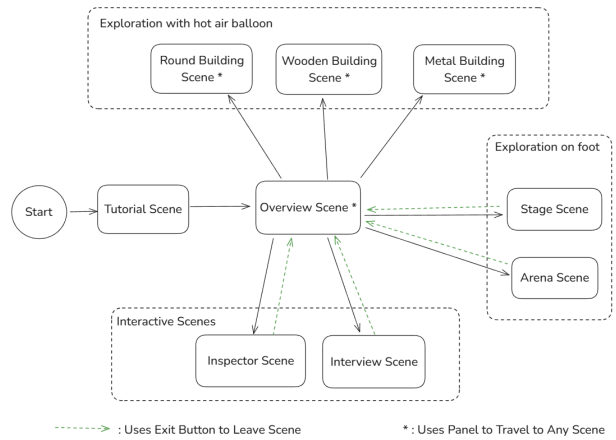


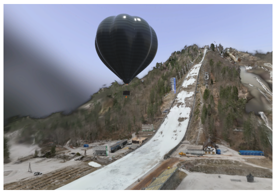
Figure 1: Scene overview diagram.

Particularly intriguing about GS content for journalism is the possibility of immersing audiences into real spaces, potentially remote, dangerous, inaccessible, or similar, while capture is relatively easy and can be done by a journalist in the field. However, as production of a full XR experience still takes time, this is less interesting for breaking news, but rather for reportage or documentary type of formats.

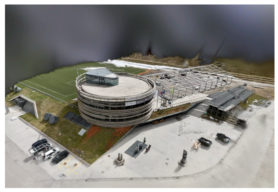
As a showcase, we centered our VR experience around the ski jumping resort in Planica, Slovenia, which is among the top locations worldwide for winter sports. The annual ski jumping event is of high importance for Slovenia. The main objective was to create a VR app to immerse users into the resort and let them experience various parts. Additionally, the topic of climate change and alpine skiing should be addressed.

An overview of our experience design is shown in Figure 1. Users enter a first tutorial scene, where they learn about interactions and navigation. Then they can access the 8 main scenes where they can navigate freely and interact. Example renderings of these scenes are shown in Figure 2. The overview scene serves as a central anchor of the experience. Users hover in a hot air balloon over a GS of the resort on a predefined spline trajectory, as illustrated in Figure 3. They can walk freely inside the ballon or even step outside. Inside the balloon there is a control panel, where users can select navigation to different scenes. There is also a 2D display which shows compilation videos, historic footage of Planica over the years, or a selection of famous ski jumps. When users enter the scene for the first time, a popular sports reporter of RTVSLO appears as volumetric video to welcome and greet them (see Figure 5).

Further, the experience contains three scenes types for exploration and interaction: 1) flyover scenes, 2) exploration on foot, and 3) interactive scenes. There are three flyover scenes which are similar to the overview scene, where the user remains in the hot



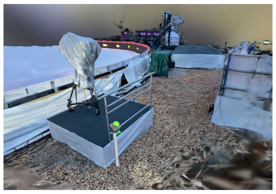
(a) Ramp (Overview scene).



(b) Round Building.

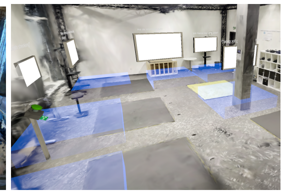
(c) Metal Tower.

(d) Wooden Building.

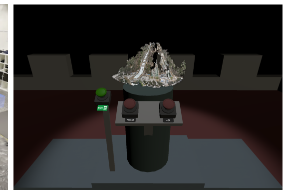


(e) Arena.

(f) Stage.



(g) Interviews.



(h) Inspector.

Figure 2: The eight available scenes for participants to explore. The first four scenes (Figures a–d) are experienced in a hot air balloon, whereas the others can be explored on foot. The scenes "*Interviews*" and "*Inspector*" contain interactive elements.

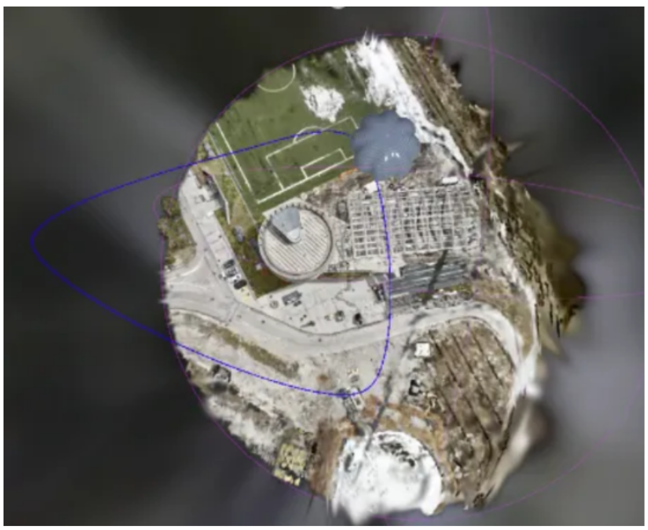


Figure 3: Visualization of the spline path.

Figure 4: Hot air balloon controls.

air balloon. Users hover around different buildings in the resort and can experience details of the GS content. Additionally 2 GS scenes are provided, which users can explore on foot, i.e. freely walk around or teleport. To return to the overview scene, exit buttons are located in these scenes.

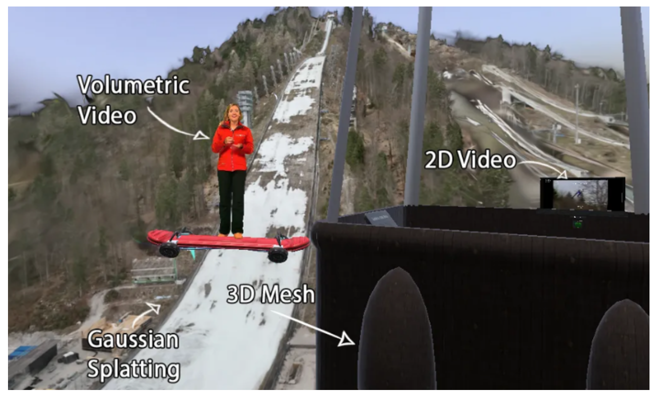


Figure 5: Example of a rendered view including various assets in one scene, including a reporter as a volumetric video.

Finally, 2 interactive scenes are included in the experience (also with exit buttons). The first is the *Inspector* scene as shown in Figure 6. Users can select different miniatures of the GS models, grab, move and inspect them freely with the controls, and even throw them away, which was informally reported to be very interesting by many users. The second interactive scene is the *Interview Room*. AFP recorded an interview with a climate change expert with a number of questions. The answers were cut separately from the 2D video and arranged individually on virtual monitors with their corresponding questions above as text, inside a virtual showroom, which itself was a GS (see Figure 7). Users can freely stroll around the room and watch the different videos.

4 Implementation

VR Planica was implemented with the tools, apps, and services available, which we evaluated in detail. From that, we devised

Figure 6: The inspector scene.

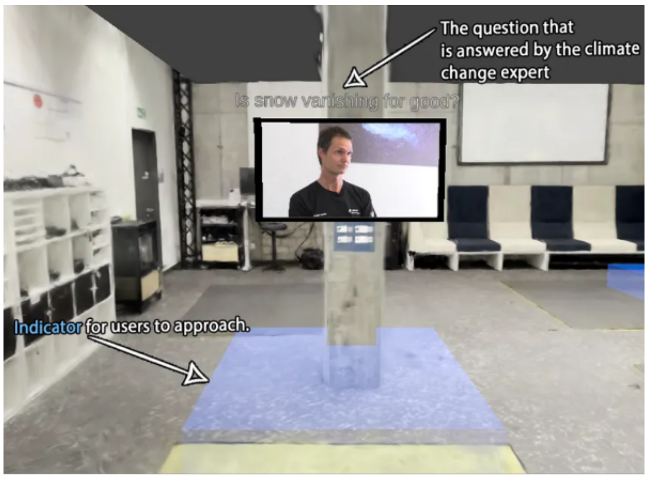


Figure 7: The interview room scene.

workflows to create VR experiences with GS content, as shown in 8. The first is the workflow used for VR Planica. The second is an updated version, which we recommend after further experiences in a follow-up project. In the following sections, we report the details of the different steps.

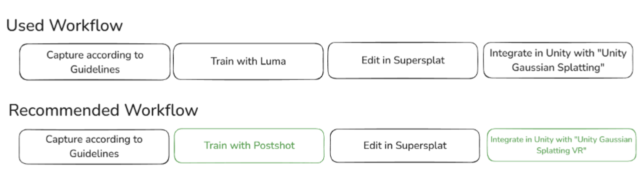


Figure 8: Workflow used for VR Planica and updated recommendation.

4.1 Capture for GS

GS relies on acquisition of multi-view imagery or video as input. Generally, the results depend on the number and quality of the input images. Although anyone can do such captures, some experience and guidance are necessary to optimize the results. Some tools integrate capture guidance into the process, which is a very useful approach. From our tests and technical experience at HSLU, we compiled a set of guidelines for the journalists in the field to do the captures. An example for drone capture is shown in 9. Based on these, a drone camera pilot of RTVSLO captured the resort for the balloon scenes, and another journalist captured the video for the ground scenes. The showroom for the interview scene is located at HSLU.

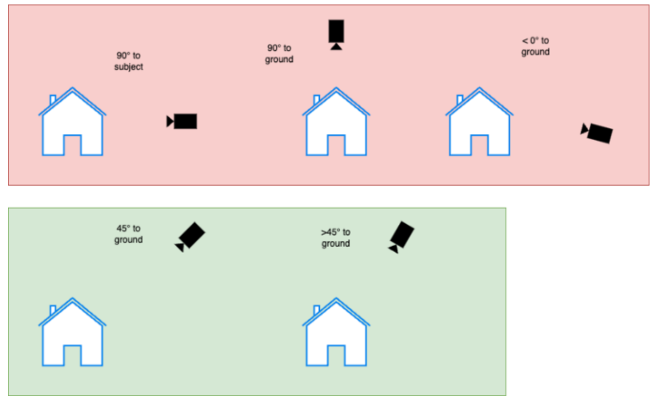


Figure 9: Recommended angles for UAV-based capture.

4.2 GS Reconstruction

The videos were then processed by the cloud service provided by Luma AI [2], to create the GS assets, which provided the best results among the available tools at the time. The drone footage was processed via the Luma web service, while the ground footage was processed via the Luma mobile app. Most of the drone captures gave satisfying results. However, most of the results from the ground floor captures were not satisfactory. Generally, GS works well for objects with circular capture and broad scenes such as our drone footage. Reconstruction of smaller spaces and rooms with outside facing capture is generally harder. There is a relation to distance and speed of motion, which requires some experience and guidance. In a follow-up project, we investigate these aspects at HSLU specifically for room capture.

In this context, we also changed our workflow to use Postshot [5] instead of Luma AI for reconstruction. Postshot provides enhanced control over training parameters. We can tailor splat training to specific use cases, such as reducing the maximum splat count for VR applications or increasing it for high-end realistic scenarios. While Postshot does not provide access to all parameters in Gaussian Splatting optimization, it offers enough control to meaningfully impact the results.

4.3 GS Editing

GS content right out of reconstruction is typically quite noisy, which may include Gaussians with extreme proportions and floating Gaussians, diminishing the visual quality. Typically, this requires clean-up and post-processing. For that we used browser-based Supersplat [7], which is currently the best tool for GS editing. It allows accurate selection of singular Gaussians by displaying them with their radius, and introduces selection tools familiar to users of image editing software such as Photoshop that work well in 3D. Export of GS content is supported in .ply format and in the novel compressed format .spz introduced by Niantic.

The topic of (post-)processing of GS content has a lot of potential for future research, and may adapt and extend principles known from point clouds. Important topics include the reduction of the number of Gaussians while keeping the visual quality, (semantic) segmentation, level-of-detail processing, compression, and more. Related tools are emerging such as GSOP for Houdini [1].

4.4 Other Assets

Besides GS content, VR Planica also includes standard assets such as 3D mesh models, animations, 2D video, audio, and images, as well as volumetric video (VV). An AI-based approach was applied for generation of the VV, which only needs a single 2D video of a person as input [21]. For that, a popular anchor person of RTVSLO was captured in a regular studio. The recorded video was uploaded to the cloud service provided by Volograms [9], which returned the VV asset in a proprietary format. This was converted into the open source VVglTF format (extension of standard glTF) [14] developed in the TRANSMIXR project for integration into the target Unity platform. The video for the interview scene was captured by an AFP journalist. 3D meshes, animations and other elements were created directly in Unity or in tools like Blender.

4.5 Unity Integration

Finally, the GS content was integrated into Unity's game engine using a dedicated plugin [17], where it was combined with the other assets to create the complete VR experience. Although this plugin was not initially optimized for VR applications, it contains advanced compression techniques that facilitate rendering Gaussian splats on hardware with limited processing power and storage capacity.

Still, the nature of GS content, not being a single object but an unstructured and unconnected set of Gaussians, poses challenges for their integration into standard workflows such as game engines. To enable interactions with users and other scene elements, proxies can be associated with GS clouds. An example is shown in Figure 10, where colliders are placed manually to enable walkable areas. Another example is shown in Figure 6, where manually placed colliders are used to allow the GS content to be grabbed, placed on a different object, or bouncing off the floor.

Manually placing objects is time consuming. Alternatively, automatic algorithms may be used, which extract meshes associated with GS data and corresponding solutions are emerging [11]. However, this may still require manual correction of inaccuracies.

5 Performance and Initial Evaluation

Since finalization, VR Planica has been presented to a large number of users at various occasions. Users appreciate the immersion and recognize the potential. In this section, we highlight performance issues and present the results of an initial user study.

5.1 Performance

GS data as generated by typical tools can be huge. The splat counts of our scenes range from 800,000 to 1.2 million, which is a serious burden on performance. Therefore, VR Planica currently runs on tethered HMD systems, such as a Meta Quest 3 connected to a PC or powerful laptop. The main reason for the large splat counts was the inability to control the splat count in Luma AI.

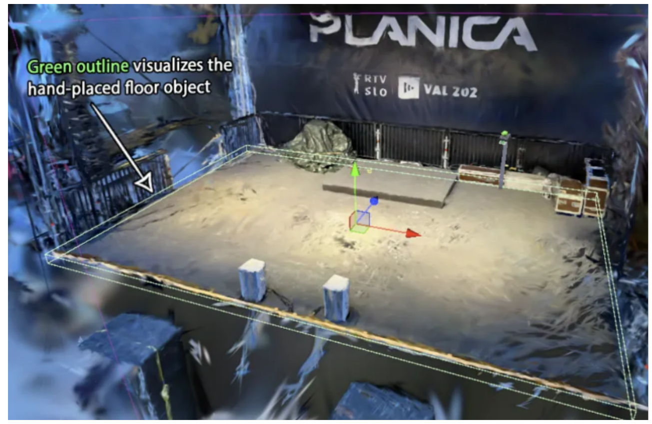


Figure 10: Example of manually placed colliders.

In Postshot, the splat count can be controlled, significantly improving performance with minimal quality loss. For future VR projects, we aim to maintain a splat count of 400,000 or lower, as demonstrated in [13] that achieved untethered VR accessibility with a lower splat count. Figure 11 shows an example of different splat counts for a scene, where the visual quality is not affected significantly.

Figure 11: Rendering quality comparison between 30k, 300k and 3m splats.

It should be noted that in some cases a reduction of splats is not acceptable. Figure 12 shows an example where the details of text are lost with very low splat counts. This may be addressed by novel algorithms for adaptive splat allocation or level-of-detail processing for GS.

Figure 12: Detail quality comparison between 30k, 300k and 3m splats.

One possibility to improve the performance in some scenes is to manually replace flat, unimportant surfaces rendered by many splats with a simple mesh. Figure 13 shows an example for the interview scene, which includes a number of 2D videos and a big GS model which affects performance in terms of rendered frames per second (fps) significantly, noticeable on even modern laptops. We removed the ceiling splats and replaced them with a simple cube. On our HP Omen laptop (Intel Core Ultra 9 185H processor, running at 2.50 GHz, 32GB Ram, and NVIDIA Geforce RTX 4070 Laptop GPU), the fps went from an inconsistent 40 fps to a consistent 60+ fps, allowing us to run the VR experience on more devices. Such manual editing is again time consuming and undesired, once more showing the need for automatic GS processing algorithms to achieve similar effects of adaptation and optimization.

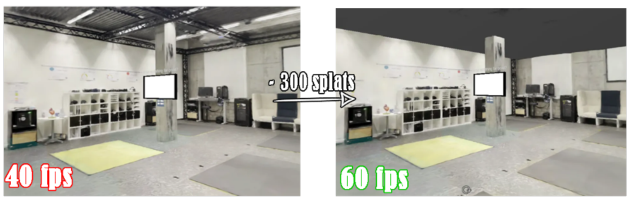


Figure 13: Performance boost with splats removal.

5.2 Initial User Study

To gain initial insights into user experience and quality, we conducted a preliminary user study. The full results will be presented in a future publication; in this paper, we report our findings on user experience.

To assess user experience, we used the short version of the User Experience Questionnaire (UEQ), the UEQ-S [19]. The UEQ is a validated and standardised tool for quickly measuring user experience of interactive products [15] and is well-suited for assessing user experience in VR [22]. The UEQ-S consists of eight items on a scale from -3 to 3. They form two subscales representing different qualities of the user experience: the hedonic subscale, which reflects novelty and enjoyment, and the pragmatic subscale, which relates to usability and efficiency.

Our study consisted of 33 participants, who were recruited from the general public, student pool and staff. The study had a well-balanced gender distribution, with 17 female participants. Ages ranged from 23 to 50 years ($M = 32.59$, $SD = 8.27$). Additionally, two-thirds of participants reported having little to no experience with VR. Participants were instructed to explore all eight available scenes in the main experience but were free to choose the order and duration of their visits. On average, participants spent 20 minutes in VR.

In our evaluation, the highest rating was achieved on hedonic qualities ($M = 1.27, SD = 1.38$), whereas pragmatic qualities were less pronounced ($M = 1.06, SD = 1.03$). The combined overall score for user experience was $M = 1.16, SD = 1.12$. To facilitate interpretation of the results, we apply the UEQ guidelines, which classify values above 0.8 as a positive evaluation [18].

Furthermore, the developers of the UEQ offer a benchmark data set to assess user experience, allowing comparisons with a wide range of studies conducted across various applications [20]. The benchmark showed that hedonic qualities rank as '*good*,' with only 10% of the results scoring higher, suggesting high originality and novelty. Pragmatic qualities, on the other hand, are considered '*below average*' (50% of results score higher), indicating an opportunity to increase clarity and usability. Together, the application ranks as '*above average*,' implying an overall positive impression, driven by its novel and original features.

These initial results are positive and promising, but a formal and detailed user evaluation will be part of our future research. Initial informal feedback from journalists was also positive regarding the potential of GS for storytelling and the ease of capture, but the rest of the workflow still requires skilled staff. We will evaluate these aspects in more detail in a user study with professionals.

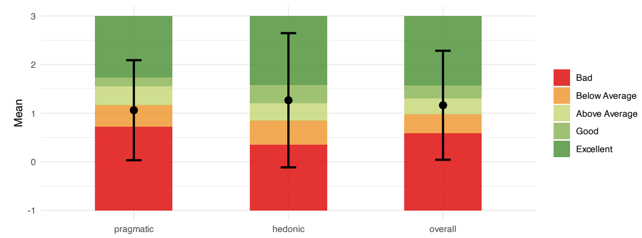


Figure 14: The UEQ-S results in reference to the UEQ benchmark.

6 Conclusions and Outlook

We presented VR Planica, our pioneering experience showcasing GS content for immersive storytelling in a journalistic context. We evaluated tools and services and devised workflows that allow others to build similar experiences. While capture can be done by anyone, it requires experience and guidance to get good results, which is also depends on the captured scenery. Technologies for editing and experience integration still require skilled staff.

In follow-up research we address optimization for rooms and indoor scenes. We also plan a comparison with classical photogrammetry methods regarding visual quality and complexity for different types on content, such as large-scale scenes which are primarily viewed from distance. Generally, the field is very active with numerous publications addressing particular aspects, and tools and services being released and updated frequently. Additional processing of GS content seems very promising for further research, for instance related to editing, resource allocation, complexity optimization or compression. Our initial user evaluation with UEQ-S and informal feedback indicates a positive response from users. In our follow-up research we will conduct a formal user study to evaluate these aspects in detail.

Acknowledgments

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