2ND INTERNATIONAL WORKSHOP

ADDITIVE MANUFACTURING AND SUSTAINABILITY

BOOK OF PROCEEDINGS

IWAM 24

INSTITUTO POLITÉCNICO DE BRAGANÇA

OCTOBER 4TH, 2024

Enhancing Realism in 3D Mapping Through Drone-Based Photogrammetry and Animated Elements

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ABSTRACT

Over time, society has increasingly adopted technology across various sectors and at different levels. Technological advancements have enabled the substitution of traditional models with animated 3D representations that offer higher levels of realism. This study explores the integration of drone-based photogrammetry with 3D modeling and animation techniques to produce realistic representations of outdoor environments, mapping the IPB-ESTIG campus, highlighting the integration of drones, software tools like Unity, and animation techniques for creating immersive environments. The objective was to provide a dynamic representation of the campus using photogrammetric methods and incorporating animated elements such as people and birds, allowing users to interact with the simulated environment. The challenges, methods, and results of this project demonstrate the viability of integrating photogrammetry, modeling, and animation to develop realistic 3D campus models and a more immersive experience in applications like urban planning, architecture, and environmental monitoring.

Keywords: Drone Photogrammetry; 3D Modeling; Animation Techniques; Immersive Environments.

INTRODUCTION

The use of 3D modeling and virtual reality (VR) technologies has revolutionized fields such as topography, architecture, agriculture, and environmental, ranging too, from urban planning to virtual simulations [1]. One of the more advanced techniques to achieve this is aerial photogrammetry, which uses aerial images to create detailed 3D representations of terrains and structures. Aerial photogrammetry has advanced with the advent of drones, allowing for more precise and cost-effective data collection [2]. This paper explores the development of a 3D VR model of the ESTIG campus, captured using drone technology, and examines the methods used to animate and render these models in real-time environments, enhancing the realism of such models by adding animated elements using Unity, thereby increasing the model's practical applications.

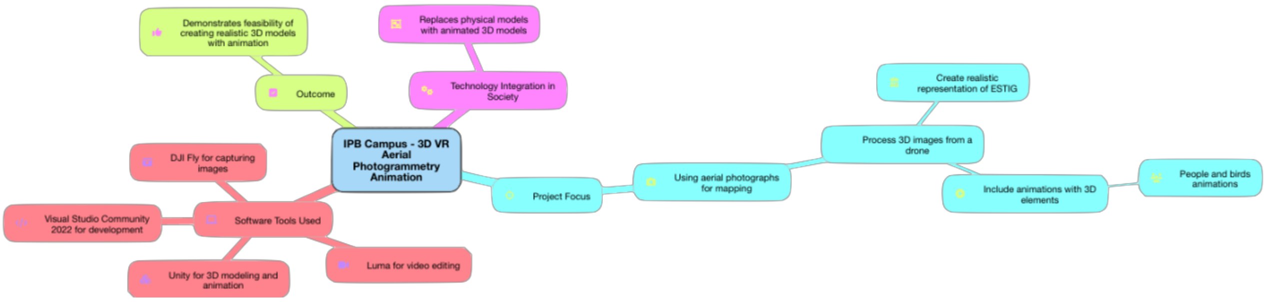

Figure 1 - Mind Map of the Process.

The goal of this work is to not only provide accurate 3D maps but also to integrate animated 3D elements such as people and birds to simulate real-world conditions more effectively.

OVERVIEW OF AERIAL PHOTOGRAMMETRY

Aerial photogrammetry involves capturing multiple aerial images at different angles to create detailed 3D models. Drones have become key tools for this technique, allowing for high-resolution mapping and data collection over large areas. Drones like the DJI Mini-series offer several advantages, such as speed, flexibility, and cost-efficiency, compared to traditional manned aerial surveys [3][4].

The ability of drones to capture 4K video and high-resolution still images allow for high-accuracy 3D reconstructions. This has made drones essential tools in fields such as civil engineering, environmental monitoring, and architecture [5]. However, drone-based aerial photogrammetry also faces challenges, such as weather dependency and limited battery life, which affect data collection efforts [6].

TOOLS AND TECHNOLOGIES

The DJI Mini 2 was used in this research to capture the aerial images necessary for developing the 3D model. This lightweight drone features a high-resolution 12 MP camera and a gimbal for stable, 4K video recording, allowing for smooth captures even in windy conditions [7]. It also offers intelligent flight modes, including QuickShots and Panorama, which streamline the process of image and video capture [8].

For processing the aerial images, the Software Luma Capture tool was employed. Luma allows for the conversion of drone images into 3D models using photogrammetry algorithms that reconstruct surfaces based on multiple perspectives [9]. The Luma AI engine also refines the texture and geometry of the 3D models, ensuring a high degree of realism in the final render [10].

To optimize the workflow, the project also utilized Unity for animation and Blender for 3D model editing. Unity's NavMesh feature was used to automate the movement of 3D elements such as pedestrians and birds within the VR environment [11].

METHODOLOGY

The first step involved flying the DJI Mini 2 over the ESTIG campus to collect aerial images. The images were captured in clear weather to ensure optimal lighting and visibility conditions. The drone was flown using the DJI Fly app, which offers intuitive control over flight paths and camera settings [12]. The images were saved on a high-speed SD card to ensure smooth recording of 4K video at 30 frames per second (FPS).

Once the data was collected, the images were processed in Luma Software to generate a 3D map. The Luma AI engine used photogrammetry techniques to analyze the spatial relationships between the images and recreate a detailed 3D model [13]. Textures from the images were applied to the model, providing a realistic depiction of the ESTIG campus, as Figure 2 displays.

The 3D model was exported from Luma in OBJ format, which is compatible with Unity for further processing and animation. Due to the size of the model, a medium-polygon version was selected to balance quality and performance [14].

Figure 2 - Obj Model vs Gaussian Splat model.

To enhance the realism of the model, animated elements were added using Unity. Pedestrians and birds were introduced into the virtual environment using NavMesh, which enables automated movement along predefined paths [15]. This approach allows for realistic interaction between the 3D models and the environment, simulating real-world behaviour such as walking or flying [16].

CHALLENGES AND SOLUTIONS

One of the primary challenges in drone-based photogrammetry is the dependence on weather conditions. Drones require stable weather with minimal wind to capture high-quality images. During this project, several flight attempts were postponed due to rain and high wind speeds [17]. A clear, sunny day was eventually selected to ensure proper lighting for the images.

Processing large 3D models can be resource-intensive, particularly when dealing with high-polygon models. To avoid performance degradation during the testing phase, a medium-polygon version of the 3D model was selected. This reduced the file size without sacrificing too much visual quality [18] (Figure 3).

Figure 3 - Path Walk movement in low model.

Additionally, the introduction of animated elements posed performance challenges. The use of object pooling helped manage resource allocation by reusing inactive objects, such as pedestrians, instead of creating and destroying them continuously [19].

OPTIMIZATION TECHNIQUES

To optimize the performance of the animated elements, an object pooling technique was employed. This technique involves maintaining a pool of inactive objects that can be reactivated as needed, reducing the overhead associated with object creation and destruction [20]. For example, pedestrians who exit the scene are not destroyed but returned to the pool, ready to be reused when a new pedestrian is introduced [21].

To further optimize rendering performance, occlusion culling was implemented. This technique ensures that only objects visible to the camera are rendered, reducing the computational load when navigating through complex scenes [23].

The use of testing intervals for pedestrian movement checks also contributed to improved performance. Instead of checking every frame for a pedestrian's destination, the system was configured to perform these checks at regular intervals, which lowered the computational demand without sacrificing the simulation's accuracy [23].

Figure 4 - Testing Pedestrian Movement.

EVALUATION AND RESULTS

The completed 3D model of the ESTIG campus was evaluated for realism, interactivity, and performance. The introduction of animated pedestrians and birds added life to the virtual environment, creating an immersive experience for users [25]. The use of Unity's NavMesh system proved effective in managing the automated movements of these elements within the environment [25].

Performance metrics, including frame rate and latency, were also measured. The medium-polygon model performed well under typical conditions, maintaining a steady frame rate even with the addition of animated elements [26]. Object pooling and occlusion culling further improved the overall system performance, allowing for real-time rendering of complex scenes [27].

CONCLUSIONS

This study demonstrates the potential of aerial photogrammetry in creating highly realistic 3D models. By integrating drone technology with advanced software tools like Unity and Luma, it was possible to create a dynamic and interactive virtual environment. The addition of animated elements enhanced the realism of the scene, while optimization techniques ensured that the system could perform efficiently in real time.

Future work could involve expanding the model to cover larger areas of the IPB campus and incorporating more complex animated elements, such as vehicles. This project provides a solid foundation for further exploration of 3D VR simulations in real-world applications [28][29].

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