6th Intercontinental Geoinformation Days

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Game development in Unity game engine using optical UAV data

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Keywords
UAV
Structure from Motion
3D Model
Virtual Reality
Unity

Abstract

Computer graphics have become highly advanced with the ability to offer users to experience a synthetic world and interact with the digital environment in a realistic manner. Within this concept, game engines are prominent tools for the visualization of three-dimensional (3D) geospatial data and for creating virtual reality (VR) based applications. Moreover, advancements in game engine technology, and easier and free access to powerful game engines have increased the number of VR-based games. Optical UAVs are the most demanded UAV systems due to their ability to produce precise and true color three-dimensional (3D) object models with a broad array of objects in different sizes and forms. However, the optical UAV technique has some disadvantages in 3D modeling including dependence on sunlight due to the passive remote sensing principle and lack of vegetation penetration capability compared to active remote sensing systems. Also, the geometry of image acquisition and low correlation land cover cause distortions and inaccurate depictions on the generated 3D models. In this study, the factors that will affect the performance of the game in the 3D model production stages and within the Unity environment are investigated and relevant solutions have been proposed.

1. Introduction

In recent years, there has been an increasing interest in unmanned aerial vehicle (UAV) technologies, which have emerged as an alternative to traditional aerial photogrammetric systems. One of the reasons why optical UAV systems are preferred is the low cost and periodically achievable very high-resolution data. In addition, the ability to fly at desired altitudes, the placement of different detection sensors, and the possibility of working in various capturing geometries are among the advantages offered by optical UAV systems. Within the scope of basic photogrammetric work steps, three-dimensional (3D) data such as digital surface models (DSM), digital terrain models (DTM), contour lines, textured 3D mesh models and vector data can be produced using UAV data (Remondino et al. 2011). Usage areas of optical UAV systems include cultural heritage documentation (Bakirman et al. 2020), archeological studies (Ulvi 2022), natural disaster monitoring (Lindner et al. 2016), smart agriculture (Almalki et al. 2021), and 3D virtual reality (VR) integration (Sefercik et al. 2022). Moreover, the creation of digital twins of non-terrain objects is among the areas where optical UAV systems are used.

Computer systems offer users the opportunity to experience an interactive digital environment through VR technology. Developments in game engines have led to an increased interest in VR technology. In addition, VR systems have become an important tool for the visualization of geospatial data and the creation of high-quality 3D models. Lately, free access to powerful game engines and the easier learning phase of game development have increased the number of VR-based games and applications. Unity game engine is a cross-platform game development platform used by a large group of users because it is free to use and it has a user-friendly interface. In this study, the factors including depth filtering level selection, gaps in 3D models due to object form, visualization of texture data in Unity, application of rendering optimization algorithms and lastly inaccurate depiction of object geometry due to the lack of penetration capability of optical UAV systems, that will affect the performance of the game in the 3D model production stages and within the Unity environment are investigated and relevant solutions are proposed.

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Cite this study

Nazar, M., & Sefercik, U. G. (2023). Game development in Unity game engine using optical UAV data. Intercontinental Geoinformation Days (IGD), 6, 13-16, Baku, Azerbaijan

2. Dataset and materials

A dataset consisting of aerial photos which were captured over the Gebze Technical University (GTU) campus, located in the Gebze district of Kocaeli province, Türkiye, using DJI Phantom 4 Pro V2.0 UAV with a 20-megapixel (MP) Sony Exmor RGB camera was utilized for producing high-quality 3D textured mesh models. UAV flights were carried out in bundle grid, polygonal and circular modes, and flight elevations were chosen as 30 m and 80 m. A total of 8333 aerial RGB photos were captured while front and side overlap ratios were determined as 80% and 60%, respectively, and the achieved ground sampling distance (GSD) was ≤ 2.2 cm. Specifications of the utilized UAV are shown in Table 1.

Table 1. Specifications of the DJI Phantom 4 Pro V2.0 UAV

DJI Phantom 4 Pro V2.0 UAV

Specification	Value
Camera	4K, HD, 1080p, 1”, effective pixel resolution 20 MP
Gimbal	3-axis (pitch, roll, yaw)
Image size	3:2 Aspect Ratio: 5472×3648 4:3 Aspect Ratio: 4864×3648 16:9 Aspect Ratio: 5472×3078
Flight duration	Max. 30 minutes
Weight	1375 g
Speed	Max 20 m/s in S-mode
Wind speed resistance	Max. 10 m/s
Outdoor positioning module	GPS/GLONASS dual
Hover accuracy range	± 0.1 m V, ± 0.5 m H (Vision); ± 0.3 m V, ± 1.5 m H (GPS)

3. Methodology

The methodology of this study consists of two main parts including the production of 3D textured mesh model generation and the creation of a game in the Unity environment (Figure 1).

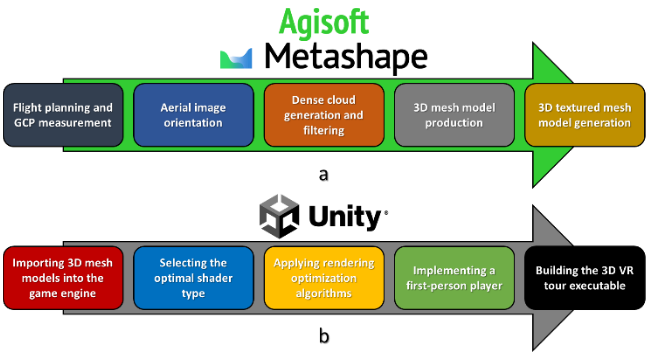

Figure 1. The methodology of the study area 3D textured mesh model generation (a) and 3D VR tour creation (b)

3D textured mesh model generation steps were carried out in structure from motion (SfM) based Agisoft Metashape Professional photogrammetric evaluation software. Before the aerial image orientation, flight planning was done in DJI Ground Station (GS) Pro software and homogenously distributed ground control points over the study area were measured using the real-time kinematic (RTK) GNSS technique. After the relative orientation of aerial photos, absolute orientation was done using GCPs with the root mean square error (RMSE) of ± 2 cm (~0.9 pixels). After the sparse point cloud production is completed as a result of aerial photo orientation, it is important to perform dense point cloud production in order to obtain a high-quality and detailed 3D mesh model. In Agisoft Metashape, depth maps containing depth information are created for dense point cloud production by processing photos. However, when creating depth maps, outliers or extreme values can be observed as a result of situations that cause noise-containing data such as differences in illumination in the photographs or unclear focus. In order to eliminate these extreme values, a depth filtering option with four filtering levels is used in the software. When these four levels are examined, the aggressive filter is recommended in areas where there are no important small details, while the mild level filter preserves the important small details that can be distinguished. Apart from that, while the moderate option gives results between mild and aggressive, depth filtering can be turned off and operations can be performed. Another important issue during the production of a 3D mesh model with high-quality and realistic depiction capability is that the objects merge with the bare topography by elongating with the effect of interpolation during the transformation from a dense point cloud to a mesh model. Lastly, 3D textured mesh models were produced using high-resolution aerial photos.

3D VR tour creation was done in the Unity game engine by the integration of produced 3D textured mesh models into the virtual environment. Firstly, 3D mesh models were imported as the wavefront .OBJ format into Unity. This format is conventionally utilized in exporting 3D mesh models and it stores 3D coordinates and triangle data and is employed by a wide number of 3D CAD software (Kato and Ohno 2009). For accurate and realistic visualization of texture data over the 3D mesh models a material object was created and texture data was implemented on this material. Then the shader type was changed from standard to unlit/texture. For improving the game performance occlusion culling rendering optimization algorithm was applied. The occlusion culling algorithm is utilized for the recognition and rendering of visible surfaces of 3D objects so that the objects positioned at the rear side of a particular viewpoint are not rendered for increasing performance and minimizing hardware bottlenecks (Coorg and Teller 1997). Users should be able to move around the 3D mesh models and interact with the environment freely. So a player with a first-person camera was added to the game environment and this player can be controlled with mouse and movement keys to provide users a realistic VR experience. In the last step, a game executable was built in Unity for providing users access to the game.

4. Results

After the methodology steps were completed, results were investigated and solution proposals were presented. Different depth filtering options were examined in dense point cloud generation (Figure 2).

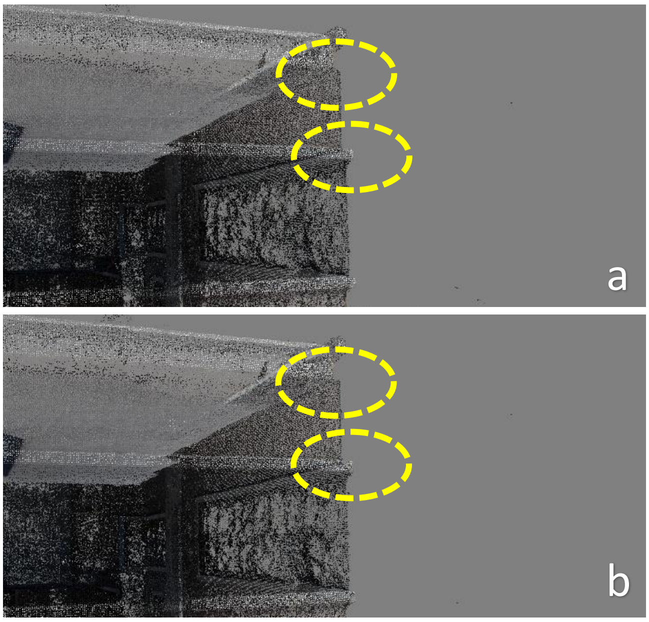

Figure 2. Produced dense point clouds when depth filtering was aggressive (a) and disabled (b)

When the depth filtering was chosen as aggressive building corners were smoother in 3D models and when it was disabled corners were sharper and seem to be more similar to the real structure. Moreover, object form seems to be another factor affecting the 3D modeling performance (Figure 3).

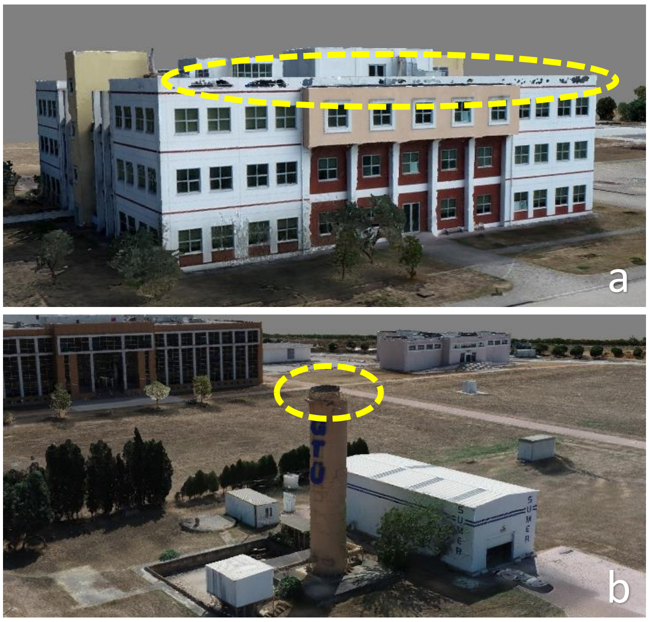

Figure 3. Gaps in the 3D model of a building (a) and a chimney (b)

In order to eliminate gaps resulting from object forms additional circular flights can be made with the UAV at oblique (inclined) camera angles (≤70°) on building facades. Another solution is to use checkerboards on objects that are thought to have issues before the UAV flight and take terrestrial photos of these objects to be used in absolute orientation, and use both aerial and terrestrial photos together in relative orientation. Moreover, the hole filling tool in Agisoft Metashape can be utilized to eliminate some of the gaps. In Unity imported texture data is applied to 3D mesh models by creating a material object and implementing the texture data on the material. However, a suitable shader type should be selected for the created material so that the texture is displayed correctly and in high detail (Figure 4).

Figure 4. Shader type of the material as standard (a) and unlit/texture (b)

The optimal shader type should be selected for accurate visualization of the texture data. The unlit/texture shader type displays the texture data more accurately and realistically compared to the standard shader type. Apart from the visual performance, the functional performance of a game is evenly important. Moreover, high polygonal data size and bottlenecks due to the limitation of utilized hardware appear to be negative factors in game performance. To improve the game performance and eliminate the hardware bottlenecks rendering optimization algorithms such as occlusion culling are applied. After the occlusion culling algorithm was applied to the created 3D VR tour frame per second (FPS) or in other words the number of frames that appears within a second, was increased to 51-122 FPS from 51-55 FPS. Boost in FPS values resulted in increased game performance and a smoother game experience for users. Optical UAV systems lack object penetration ability due to their operation based on the remote sensing principle. Especially in dense vegetation cover, forests, and underground passes a low number of points are generated due to overlaying objects obstructing the viewpoint of the optical UAV systems. The resulting 3D mesh models are inaccurate and incomplete depictions of real objects because of this problem (Figure 5). In such areas, multi-return laser scanning capable UAVs may be used, but since the original color information of the point cloud is also provided by digital cameras integrated into the laser scanner, it is not possible to obtain the original color.

Figure 5. 3D model of the underground pass produced using RGB UAV dense cloud (a) and using the fusion of RGB UAV dense cloud and colored terrestrial laser scanner dense cloud (b)

Terrestrial photogrammetry is also not recommended due to correlation problems in orientation. In light of all these issues, the most accurate production of 3D models in their original color is possible with the fusion of optical UAV and colored terrestrial laser scanner data in the correct geometry.

5. Conclusion

Within the scope of this study, the factors in the 3D textured mesh model production and in the integration of generated models into the Unity engine are investigated for improving game performance, and encountered problems are explored with relevant solution proposals. It has been observed that the parameters affecting the 3D modeling performance in SfM-based image matching software including the production of dense point clouds, generation of 3D mesh models, and appropriate texture graphics, significantly affect the performance of the created game. Apart from factors affecting 3D modeling performance, elements such as the selection of proper shader type for texture applied material object, and application of occlusion culling rendering optimization algorithm appear to greatly affect the both visual and functional performance of the game. Object geometry is another aspect affecting visual performance, gaps formed due to object forms lead to 3D mesh models with inaccurate geometry and decreased game performance. Lastly, the lack of penetration capability of optical UAV systems emerges as another issue affecting 3D modeling performance, especially in areas obscured by overlaying objects. A solution proposal for this issue is merging the optical UAV dense cloud with the color terrestrial laser scanner dense cloud. In conclusion, the game performance of the created 3D VR tour is affected greatly by parameters in 3D model generation and factors in setting up the game environment.

References

Almalki, F. A., Soufiene, B. O., Alsamhi, S. H., & Sakli, H. (2021). A low-cost platform for environmental smart farming monitoring system based on IoT and UAVs. Sustainability, 13(11), 5908. https://doi.org/10.3390/su13115908

Bakirman, T., Bayram, B., Akpinar, B., Karabulut, M. F., Bayrak, O. C., Yigitoglu, A., & Seker, D. Z. (2020). Implementation of ultra-light UAV systems for cultural heritage documentation. Journal of Cultural Heritage, 44, 174-184. https://doi.org/10.1016/j.culher.2020.01.006

Coorg, S., & Teller, S. (1997). Real-time occlusion culling for models with large occluders. In Proceedings of the Symposium on Interactive 3D Graphics, 83-90, Providence RI, USA.

Kato, A., & Ohno, N. (2009). Construction of three-dimensional tooth model by micro-computed tomography and application for data sharing. Clinical oral investigations, 13, 43-46. https://doi.org/10.1007/s00784-008-0198-4

Lindner, G., Schraml, K., Mansberger, R., & Hübl, J. (2016). UAV monitoring and documentation of a large landslide. Applied Geomatics, 8, 1-11. https://doi.org/10.1007/s12518-015-0165-0

Remondino, F., Barazzetti, L., Nex, F., Scaioni, M., & Sarazzi, D. (2011). UAV photogrammetry for mapping and 3D modeling–current status and future perspectives. International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences, 38(1), 25-31. https://doi.org/10.5194/isprsarchives-XXXVIII-1-C22-25-2011

Sefercik, U. G., Kavzoglu, T., Nazar, M., Atalay, C., & Madak, M. (2022). Creation of a virtual tour .exe utilizing very high-resolution RGB UAV data. International Journal of Environment and Geoinformatics, 9(4), 151-160. https://doi.org/10.30897/ijegeo.1102575

Ulvi, A. (2022). Using UAV photogrammetric technique for monitoring, change detection, and analysis of archeological excavation sites. Journal on Computing and Cultural Heritage, 15(3), 1-19. https://doi.org/10.1145/3522742