

RESEARCH OF PHOTOGRAMMETRY TRANSFORMATION INTO VIRTUAL REALITY ENVIRONMENTS SUITABLE FOR USE IN VIRTUAL REALITY

Nicolas Canale Romeiro¹
André Salomão²
Leticia Maria Fraporti Zanini³
Milton Luiz Horn Vieira⁴

Abstract: *The maps of Santa Catarina are created through the efforts of the Government of the State of Santa Catarina, specifically the Department of State for Sustainable Economic Development (SDS). These maps are freely accessible to the public through the Geographic Information System (GIS) tool, known as SIGSC. The technology of virtual reality presents inherent challenges, as in the process of creating an experience for it, the designer must be aware of the best practices to avoid adverse effects. The objective of this research is to examine methods for transforming photogrammetry files from the SIGSC project into viable scenarios suitable for use in virtual reality environments. The initial stage of this research was to comprehend the information within each file. In conclusion, both procedures were deemed valid for recreating the maps inside the virtual environment suited for virtual reality.*

Keywords: *Photogrammetry; Virtual Reality; Environment.*

Resumo: *Os mapas de Santa Catarina são criados por meio dos esforços do Governo do Estado, especificamente pelo Departamento de Estado para o Desenvolvimento Econômico Sustentável (SDS). Esses mapas são livremente acessíveis ao público por meio da ferramenta de Sistema de Informação Geográfica (SIG), conhecida como SIGSC. A realidade virtual apresenta desafios inerentes, já que no processo de criar uma experiência para ela, o designer deve estar ciente das melhores práticas para evitar efeitos adversos. O objetivo desta pesquisa é examinar métodos para transformar arquivos de fotogrametria do projeto SIGSC em cenários adequados para ambientes de realidade virtual. A etapa inicial dessa pesquisa foi compreender as informações contidas em cada arquivo. Em conclusão, os procedimentos foram considerados válidos para recriar os mapas dentro do ambiente virtual para realidade virtual.*

Palavras-chave: *Fotogrametria; Realidade Virtual; Ambiente.*

Resumen: *Los mapas de Santa Catarina son creados mediante los esfuerzos del Gobierno del Estado, específicamente por el Departamento de Estado para el Desarrollo Económico Sostenible (SDS). Estos mapas son de acceso libre al público a través de Sistema de Información Geográfica (SIG), conocida como SIGSC. La realidad virtual presenta desafíos inherentes, ya que en el proceso de crear una experiencia para ella, el diseñador debe estar*

¹ Programa de Pós-Graduação em Design – Universidade Federal de Santa Catarina (UFSC) – Florianópolis – Brasil. ORCID: <https://orcid.org/0000-0002-9938-8046> - nicolas.romeiro@ufsc.br

² Programa de Pós-Graduação em Design – Universidade Federal de Santa Catarina (UFSC) – Florianópolis – Brasil. ORCID: <https://orcid.org/0000-0002-3420-8614> - andresalomao3d@gmail.com

³ Graduação em Animação – Universidade Federal de Santa Catarina (UFSC) – Florianópolis – Brasil. ORCID: <https://orcid.org/0009-0008-8400-5058> - leticiamfz@gmail.com

⁴ Programa de Pós-Graduação em Design – Universidade Federal de Santa Catarina (UFSC) – Florianópolis – Brasil. ORCID: <https://orcid.org/0000-0002-6646-2799> - milton.vieira@ufsc.br

consciente de las mejores prácticas para evitar efectos adversos. El objetivo de esta investigación es examinar métodos para transformar archivos de fotogrametría del proyecto SIGSC en escenarios adecuados para realidad virtual. La etapa inicial de fue comprender la información contenida en cada archivo. En conclusión, los procedimientos fueron considerados válidos para recrear los mapas dentro del entorno virtual para realidad virtual.

Palabras clave: Fotogrametría; Realidad Virtual; Entorno.

1 INTRODUÇÃO

With multiple pictures of the same object, captured from different positions, it is possible to calculate its three-dimensional coordinates. This concept is the primary objective of photogrammetry, to determine the three-dimensional object or the terrain coordinates for points represented in the multiple pictures taken of it.

The maps of Santa Catarina are created through the efforts of the Government of the State of Santa Catarina, specifically the Department of State for Sustainable Economic Development (SDS). These maps are freely accessible to the public through the Geographic Information System (GIS) tool, known as SIGSC.

The Santa Catarina Geographic Information System (SIGSC) is a test project created by the government of the state of Santa Catarina that gathers high accuracy geographic data in order to help the sustainable development of the State. The Aero photogrammetric Survey has more than 70,000 aerial photos, color and infrared orthophoto mosaics, altimetric digital models, hydrographic restitution, hydrographic basins and water infrastructure, with potential for use in various activities processed for territorial and environmental management.

The concept of virtual reality started back in the 1960s when Ivan Sutherland attempted to describe it in one of his manuscripts as a window through which the user perceives the virtual world, like they are looking, feeling and hearing the reality which they can interact with (Cipresso, Giglioli, Raya & Riva, 2018). And has since then been used in research in multiple study fields (Bouvier, Sorbier, Chaudeyrac & Biri, 2008), such as medicine, with training for bone marrow collection and breast biopsy procedures (Machado, Moraes, Nunes & Costa, 2011), as well as therapeutic tool for motor rehabilitation of patients who have had a stroke (Soares, Woellner, Andrade, Mesadri, Bruckheimer & Hounsell, 2014).

Virtual reality has also been used in UAV simulators due to its ability to allow the creation of an immersive virtual environment (Gouveia, 2016) and a safe environment for practitioners to learn how to pilot a UAV without putting themselves in severe health risks (Sherman & Craig, 2018)

The technology of virtual reality presents inherent challenges, as in the process of creating an experience for it, the designer must be aware of the best practices to avoid adverse effects on user's side (Yao, Heath, Davies, Forsyth, Mitchell & Hoberman, 2014)

The objective of this research is to examine methods for transforming photogrammetry files from the SIGSC project into viable scenarios suitable for use in virtual reality environments. (Cipresso, et al., 2018)

2 CONCEPTS

This chapter provides an overview of the main themes and concepts explored in this research and establishes the theoretical foundations of the following chapters. It examines key topics, theories and empirical studies to provide a comprehensive understanding of the subject.

2.1 PHOTOGRAMMETRY

Photogrammetry is defined as the science and technology in charge of acquiring reliable information through sensor-captured images, aimed at the reconstruction of it in a three-dimensional space, also known as object space, from a set of two-dimensional images, referred to as the image space (Coelho & Brito, 2007)

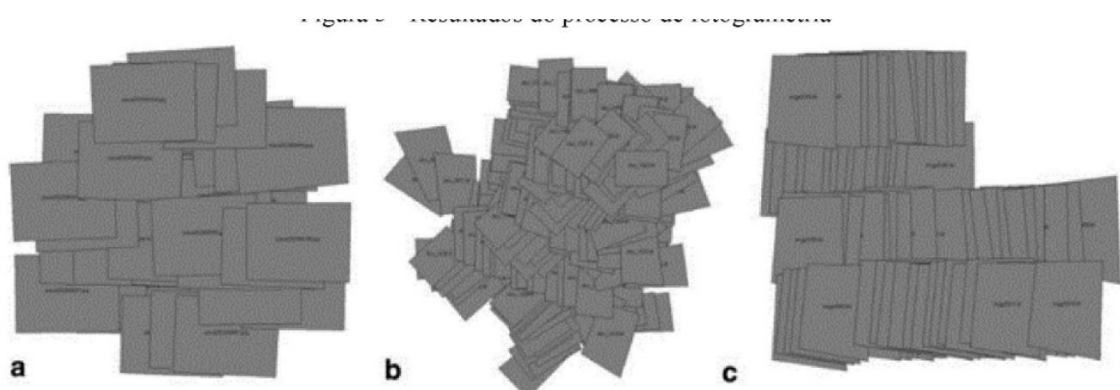
The mapping using photogrammetry techniques has been carried out using UAVs (Unmanned Aerial Vehicles) due to different factors. These includes the possible lower cost of the equipment, which gives a competitive edge in operational costs, the ability to have high level of automation in the aerial surveying process, ease of adaptation in case of coverage in small areas, the high repeatability of surveys at low cost, results being acquisition in high-resolution aerial photography, capability of having real-time image viewing, repeat of flights in case of errors, low safety risks in case of accidents (due to their lightweight nature), and shorter planning time (Gonçalves & Henriques, 2015).

- The capture can be performed in three different ways: manual (a), assisted (b), or autonomous (c), with the most indicated depending on the specific needs of the project.
- Manual mode: The images overlap, and the acquired geometry is generally irregular since the images are captured at intervals.
- Assisted mode: A low-cost navigation system is used to guide the UAV through a predetermined path. The results are images that overlap and are still irregular.

- Fully autonomous mode: Requires a high-quality navigation system to work autonomously, with minimum human-input.

There are multiple types of files derived from digital Photogrammetry. For this research, we will be focusing on two of them, The Digital Surface Model (DSM) and the Digital Terrain Model (DTM). The Digital Surface Model (DSM) can be described as a numerical representation used to depict a particular physical surface of the terrain, such as the topography. It provides a digital portrayal of the surface by assigning elevation values to specific points. While Digital Terrain Model can be defined as a digital representation of captured from elevations of the terrain, which means, a numerical depiction of the altitudes or elevations of a specific points of the captured terrain (Coelho & Brito, 2007). An example can be seen in Figure 1.

Figure 1 - Phogrametry example



Source: Nex And Remondino (2014)

2.2 VIRTUAL REALITY

For this paper, the chosen concept of VR is the one presented by LaValle (2016), which says that Virtual Reality is "Inducing targeted behavior in an organism by using artificial sensory stimulation, while the organism has little or no awareness of the interference.". He then proceeds to provide the following definitions for key terms:

- Desired Behavior: is the subject organism experiencing the simulation created
- Organism: A living being immersed in the virtual reality environment
- Artificial Sensory Stimulation: Deceiving and replacing one or more senses of the organism with simulated stimuli
- Awareness: The lack of perception by the organism regarding the interference by the real world, feeling present in the virtual reality that it is exposed to.

In the development of assets for virtual reality environments, it is necessary to optimize them in order to ensure that the final application doesn't have a high polygon count or an excessive numbers of objects on the screen due to the fact that too much polygon can and will affect the virtual environment performance, and therefore disrupt a smooth and immersive VR experience. (Tang & Ho, 2020)

2.3 UTILIZED SOFTWARE

In this subsection, we will explore the various software programs that have been used during this research. These programs play an important role in the execution and analysis of the study and provide valuable tools and functions that contribute to the achievement of research objectives.

2.3.1 3DS Max

3ds Max is a powerful 3D generalist software developed by Autodesk. It was released in 1990 and is widely used in industries such as film, video game development, architecture, and product design. The software excels in rendering, animation, and 3D modeling, offering advanced tools for creating high-quality visualizations and realistic character animations. It supports various rendering engines, has a wide range of animation capabilities, and provides flexible 3D modeling tools. With its plugin support and regular updates from Autodesk, 3ds Max remains a highly respected tool that empowers artists and designers to create impressive 3D content.

2.3.2 Unreal Engine 4

Unreal Engine 4, developed by Epic Games, is a versatile game engine software released in 2014. It is widely used in various industries for game development, architectural visualization, simulations, virtual reality, augmented reality, video editing, and sound design. With its advanced features and real-time rendering capabilities, Unreal Engine 4 empowers creators to build immersive and visually stunning experiences across multiple platforms. Epic Games continues to support and enhance the engine, providing resources and updates to its vibrant community of developers and artists.

2.3.3 L3DT

Bundysoft developed a tool called L3DT, a software designed to generate realistic terrain heightmaps and textures. It offers a comprehensive set of features such as creating detailed landscape, by employing algorithms and techniques, including erosion control, hydrology, thermal weathering, and texturing, to produce terrain maps. The software also has a customizable interface, making possible to generate terrains for different applications such as games, virtual reality environments, simulations and visualizations.

3 DEVELOPMENT

This chapter focuses on the development of research, using the concepts and software programs mentioned above. It describes in detail the methodology used, which incorporates theoretical frameworks and practical tools to guide the study. The chapter serves as a comprehensive guide to understanding how research has been conducted, highlighting the integration of concepts and software programs into the research process.

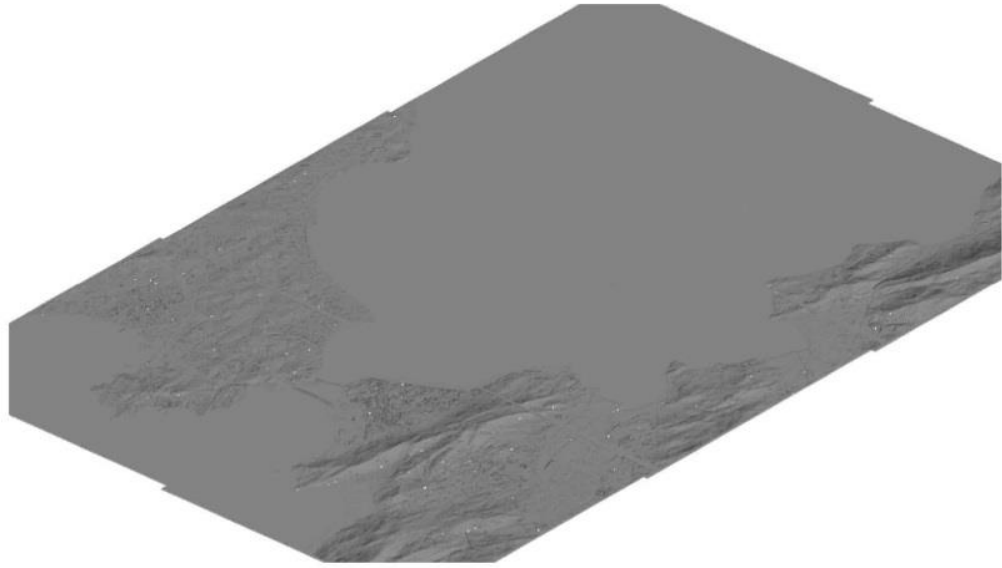
The initial stage of this research was to comprehend the information within each type of terrain file. The “Terrain Model” and “Surface Model” maps were both comprise of two file types per photo, a) a greyscale image and b) geographical data (altitude, longitude and latitude) corresponding to the photo’s original captured location. As for the “Ortophoto Mosaic” map, it encompasses a colored image captured from the site in a top-view angle, similar to what is seen in applications such as Google Maps, which will not be used in this research.

Even though there were three types of maps provided by the Government of the State of Santa Catarina, only two of them were utilized as study objects. Both would be then exported to Unreal Engine 4 (version 4.18 used at the time of the research), in order to turn them into virtual environment suited for virtual reality.

2.4 3DS MAX APPROACH

The first approach was to convert the Terrain Model and Surface Model image files into 3D models using software programs commonly used for traditional 3D, as Autodesk Maya, Autodesk 3Ds Max, and Blender. And then to subsequently export these models to Unreal Engine 4. The terrain model can be seen in Figure 2.

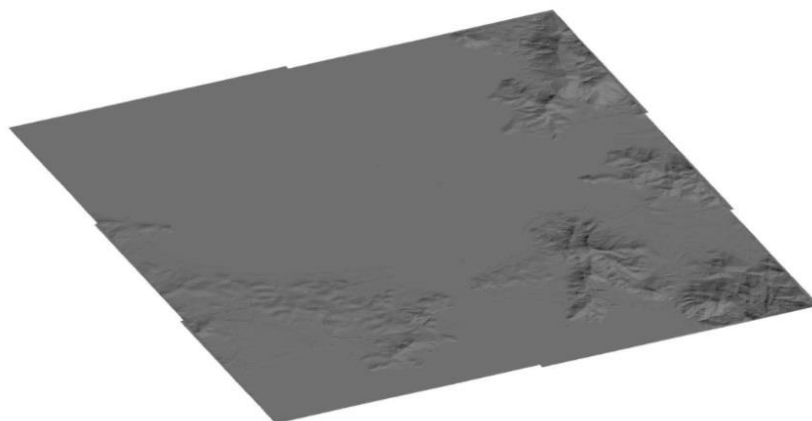
Figure 2 - Terrain Model



Source: Salomão (2020)

So, we used 3Ds Max to create a plane and applied the displacement effect on it using both map's greyscale maps to test the results. The displacement tool takes the greyscale to create the difference in heights on the terrain, molding it to how it looks in real life. The problem with this approach, was that the more realistic terrain we wanted to create, the higher the polygon count of the plane needed to be, and the higher that count was, the less viable for a virtual environment reality the created model was. The surface model can be seen in Figure 3.

Figure 3 - Surface Model



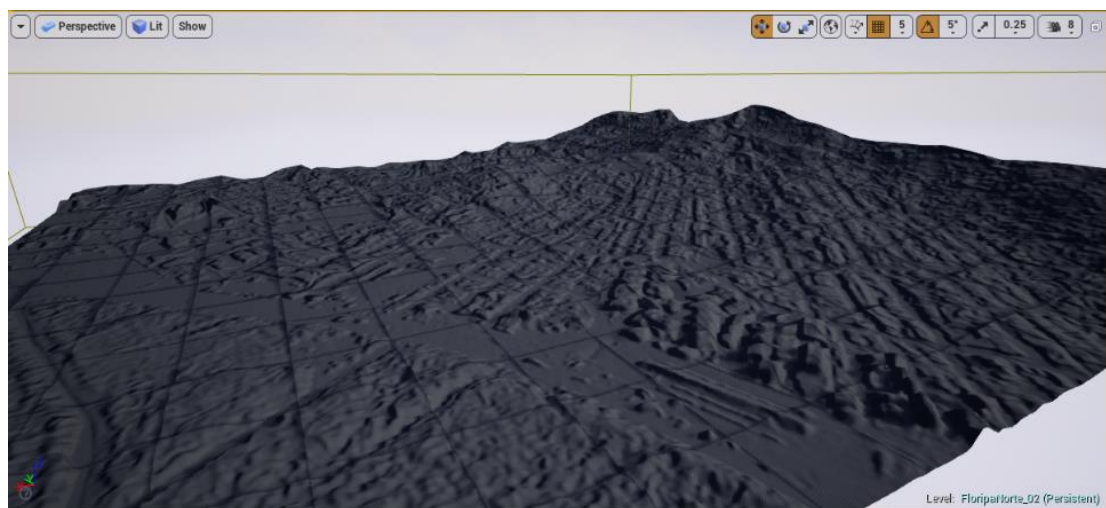
Source: Salomão (2020)

Therefore, in order to create the environment to the likes of what we needed, a lot more tests would be required, trying to guess the perfect balance between realism and performance. So, we deemed that in order to create a virtual environment proper for virtual reality, another type of approach was necessary.

2.5 L3DT APPROACH

The second approach involved converting the images files into a format compatible with the Landscape tool within Unreal Engine 4, which was specifically designed to create proper, optimized terrain for virtual environments. So, a third-party software called L3DT by Bundysoft was used to convert the images of both type of maps into a format that was compatible with Unreal Engine 4. An example of L3DT approach can be seen in figure 4.

Figure 4 - Model in Unreal Engine



Source: Salomão (2020)

This approach had its advantages, such as the tool from unreal engine 4 was optimized for game scenarios, automatically adjusting the level of detail according to the player's position on the map, and allowed more customizable options to adjust values, making the performance hit less of an issue, increasing its suitability for virtual reality.

But as the previous approach showed, the increase in performance also come at a cost of visual quality and fidelity, potentially leading to undesired outcomes.

4 CONCLUSION

In conclusion, both procedures were deemed valid for recreating the maps of Santa Catarina inside the virtual environment suited for virtual reality. The first procedure remains a

viable option for transforming photogrammetry files into virtual environments maps due to not necessarily needing to work with Unreal Engine and being able to be exported to different software that are able to recreate virtual environment in a tridimensional space.

However, the second procedure emerges as the ideal choice for virtual reality applications due to being able to work integrated in the Landscape tool from Unreal Engine 4, which was specifically developed for this type of work, and offers better tools to handle the virtual environment performance tax on current hardware. It is important to note that while this approach offer better performance, it also might come at a cost of visual fidelity in certain scenarios, especially when looking at it from a distant point of view inside the virtual environment.

In future efforts, it is recommended to expand the scope of the landscape tool in the updated version of Unreal Engine 5 and use new tools to explore the feasibility of incorporating large cities into the virtual environment, rather than focusing on one part, as described in the research.

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