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Design Variations of Mount Olympus' Relief in a Virtual Reality Environment

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Abstract: The purpose of this article is to describe the procedures and practices that were followed during the early stage of a research entitled "Use of game engines in the design and implementation of Mount Olympus in a virtual reality environment" - funded through a scholarship by the Stavros Niarchos Foundation - and to present the results of the design process that was followed. The main aim of this stage was an attempt to approach the modern methodologies of representation and production of virtual interactive landscapes as well as to familiarize with the use of the available software for the creation of interactive representations that can be integrated into a narrative digital geo-environment.

Keywords: Virtual reality, Game engines, Representation, Digital landscape, Digital design

Prologue

The design of virtual interactive representations is an interdisciplinary area of research and practice that is rapidly evolving. The recent international academic discourse on representation and virtual space has linked the creation of virtual environments with architectural research. Among the emerging technologies and tools of digital creation, virtual reality has been distinguished in recent years, due to the exceptional capability of spatial representation, multimodal communication and the potential to integrate any conditions in any given scenario. Today, the use of immersive virtual environments constitutes a practice of spatial and morphological design, which is applied in various fields such as the industrial, architectural, urban and landscape design or even cultural and educational applications.

According to Hilary McLellan, these virtual environments can be defined as a class of computer-controlled multisensory communication technologies that allow more intuitive interactions with data and involve human senses in new ways (McLellan, 1996). More specifically, the basic condition that is met during the use of a digital environment, is the need for modeling and simulation of various scenarios and conditions as well as the multi-sensory approach and understanding of space that can directly reveal additional aspects of the design processes such as the comprehension of the represented information, the analysis of the necessary actions, the requirements of the audiovisual synthesis, the tactics of interaction, the thorough analysis of the narration and the compositional elements of the dominant atmosphere. These extra qualities and perspectives of virtual space, and especially the ability to immerse in it, are the main advantages of this design approach.

Game Engines as tools of Digital Design

In order to create a virtual environment, the use of certain design software is needed. Today the dominant tools for the implementation of virtual reality applications are game engines. More particularly, game engines are software platforms that specialize in the design and production of video games. They consist of special programs that render graphics, manage sound, motion, animations and physics, control artificial intelligence behavior or even particle systems. Today, there are more than 650 game engines (Moddb). The most popular, multi-functional as well as free for academic use, game engines are the CryEngine 5, the Unreal Engine 4 and Unity Engine 5.

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Selection of Design Approach

In order to design and implement a digital representation of a physical environment, it is necessary to define the primary scope of the representation. If there is a need for realistic simulation and scientific study of a place which demands the detail modeling of the physical characteristics of an area, the visualisation and comprehension of geospatial data and the conduction of measurements with specific requirements, then the design approach should involve the use of official geospatial data, special visualisation software, algorithms and methods for theoretical modelling, calculating and forecasting changes as well as photogrammetry and remote sensing methods with devices such as drones. Additionally in this case, Geographical Information Systems (GIS) that produce and manage spatial information and their associated properties are used extensively.

Many efforts have been made recently to enhance the representation capabilities of a GIS using new methods of digital representation and geo-reference. Particularly, in recent years, the use of virtual reality has been extended and applied to GISs and thus defining a new category of geospatial digital systems known as Virtual Geographic Environments (VGEs). In general, a VGE is an integrated virtual space used to simulate and analyze complex georeferenced phenomena combined with the geographical visual representation of an area (Jedlička & Hájek, 2014).

Without any doubt, the aforementioned approaches are valuable, scientific tools for the collection, the analysis, the processing and the management of geospatial data. However, their implementation involves considerable difficulties such as high cost and time consumption as well as the requirement of specialized equipment and properly trained staff. Also, the priority of a GIS or a VGE is the reliability of information and geospatial detail, not the quality of visual representation of the landscape and thus its use is not considered appropriate in the case where the primary goal of the representation is the audiovisual fidelity of the natural environment and the immersion in it. More particular, Kirill Zhigalov argues that modern GISs are significantly devoid of visual representation quality and therefore it is important to modify and combine them with a game engine in order to produce new and better tools for the representation of geospatial information (Zhigalov, 2016). Additionally, Bergen et al, while commenting Orland’s article (Orland, 1993) on the use of digital simulations in both urban design and landscape design, stated that exclusively data-driven models have been too abstract to serve as the basis for visual quality decision making (Bergen, McGaughey & Fridley, 1998). Finally, it is a fact that the main benefits of the usage of these systems are mainly adopted by the scientific community and cannot be used by a casual user who wants to directly experience a virtual landscape, immerse and wander in it and gain direct empirical knowledge about its morphological features, vegetation, weather or the flora and fauna of the area.

Moreover, the quality of the visual representations of a VGE, although that is improved compared to the past, it remains at a low level, compared to the realism of the representations that can be achieved in contemporary game engines. Similarly, the term "game quality" that is often used in the literature of data visualization emphasizes the superiority of game engines in the field of graphics quality and immersion.

Representation Data and Immersion

It is self-evident, that during the design of the digital representation of an immersive interactive environment it is necessary to search for and collect various geospatial data. Indicatively, it is mentioned that data such as the tree cover density of an area or the living area limits of an animal species could be certainly used within the representation, while other geospatial data indicate also valuable quantities and qualities of the constituent elements of the environment that is being represented. However in this case, the range of the beneficial information is limited, due to the fact that these data only quantify and geo-locate objects or phenomena. Therefore they do not contribute significantly compared to other type of data, to the overall experience and immersion in a digital interactive environment which is a key issue of representation in virtual environments. In particular, what is implied is that the exact information which is related to the tree cover density is not as important as the overall atmosphere of the forest, the shadows of the trees or the birds that fly among them. For this reason, the collection of photographs of the flora and fauna of a region that will provide the necessary data for 3D modeling, is more important for the immersion than the geospatial information which is related to the exact population of a certain species.

In conclusion, if the scope of a digital representation is the simulation of the atmosphere of an area, the interaction with the surroundings, the immersion and the experiential presence that the virtual environments provide, then the use of data that are not necessarily georeferenced could contribute to an optimal design solution. Furthermore the simulation of such an environment can be altered and expanded whenever necessary, with the functionality and credibility of additional geospatial data.

Basic Design Methodology

The design methodology of a digital representation by using a game engine is not a certified and strictly defined method but rather a process of progressive and cumulative synthesis. In particular, although that there are individual tasks which are definitely preceded by others, the basic methodology includes stages that depend on the overall design process, and thus their implementation order can be changed. However, there are three distinct stages which constitute the creation process of the representation of the physical environment, which are implemented and imported into the engine in the following order. First, the digital height map of the terrain which consists the relief of the area. Second, the textures of the ground that represent soil and rock. These textures are a product of digital synthesis through special software or even physical world images. Third, three-dimensional models of other environmental elements such as vegetation, fauna, water bodies and clouds, special landforms or any other design element and finally light. The manipulation of light during the final rendering of the environment is crucial, as it is one of the important components of the atmosphere of the represented landscape. As the title implies, this paper refers only to the basic design methodologies of a digital relief for use in a virtual reality environment and especially Olympus' relief.

Implementation of Design Variations

As mentioned previously, the basic digital file that is needed in order to implement a virtual relief is the height map of the area. In the field of computer graphics, a height map is a greyscale image file, in which the highest point is represented by white color and the lowest by black. This file can be created manually or automatically with the use of special tools known as terrain editors. These tools are included in all contemporary game engines. Also, a height map file can be synthesized and edited with specialized software like World Machine, Terragen, World Painter, World Creator and others. Additionally, if the scope of the representation is the simulation of an area, then the height map can be generated by contour lines which can be obtained from a GIS system, from satellite data or even data that can be found in virtual globe software like Google Earth or ArcGIS Earth. For the first stage of the research, height data from the satellite system ASTER (Global DEM V2) were used, which are the most recent satellite data set with resolution of 30 meters per pixel (Figure 1).

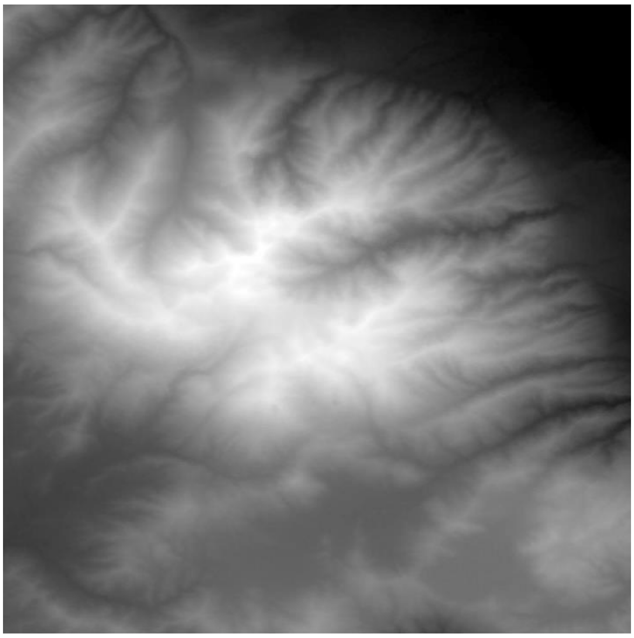

Figure 1. Basic height map of the research area

The first attempt to implement a 3D model of mount Olympus by using the basic height map was done with the use of Terragen 4 software (Figure 2).

Figure 2. Basic 3D model of Mount Olympus

A version of the same model with the addition of a vegetation layer was also implemented in Terragen 4 (Figure 3).

Figure 3. 3D model of Mount Olympus with the addition of a vegetation layer

By using the same model as a height map guide, the simulation of three progressive stages of surface erosion on the mountain's relief was attempted (Figure 4).

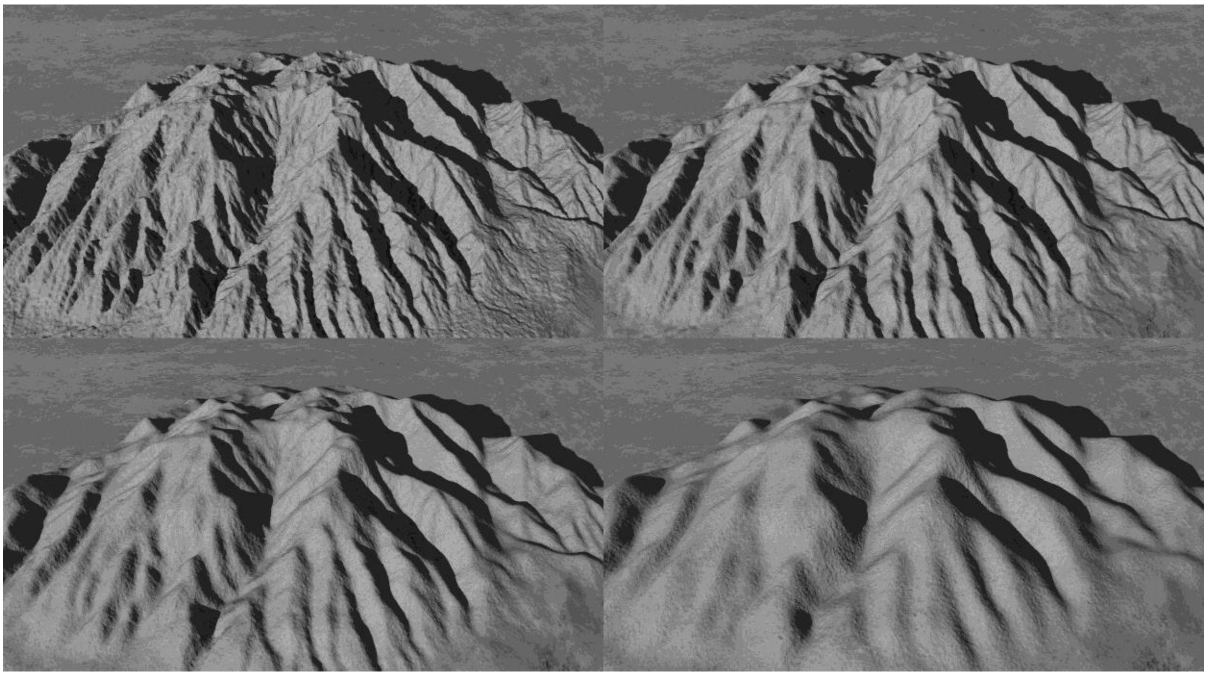

Figure 4. Erosion stages of the Olympus' relief and the intact relief (upper left corner)

At this point it is useful to mention that these images are not accurate geo-morphological simulations of the mountain or its geology but rather representational metaphors of Olympus. According to this fact the models in Figure 5 represent the mountain's image if it was constituted by different rock types. These models are processed and implemented with the use of World Machine software. In the first case (a) the mountain is represented by a rock type that is similar to the real one. In the second case (b), Olympus is constituted by sedimentary rocks in arid, desert climate conditions and in case (c) the basic rock type of the mountain is granite and the mountain's slopes are covered in moss.

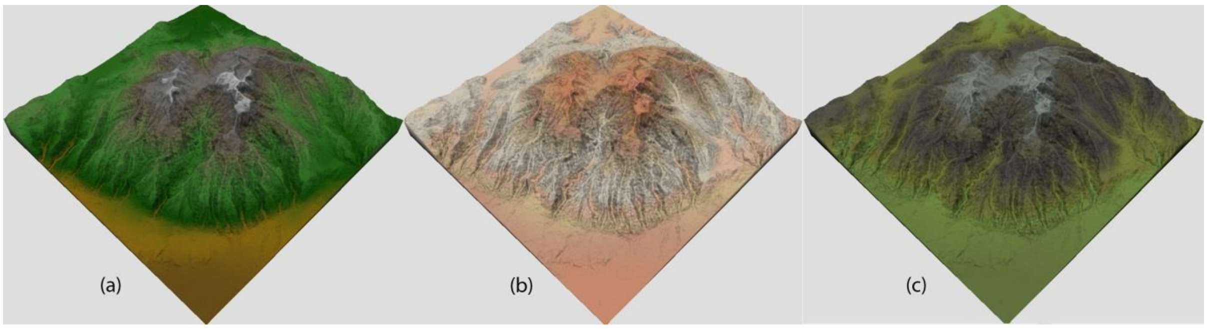

Figure 5. Two different rock type versions (b) and (c) of the basic model (a)

The next models that were also implemented in World Machine software, represent the alteration of mountain's relief through time, during a glacial erosion process. In Figure 6 you can see the intact relief (a), the first stage of glaciation (b) and the final stage of the hypothetical erosion (c). As mentioned before, the exact simulation of these environments is not as important for the immersion metaphors as the alternative narrations that virtual realities can provide.

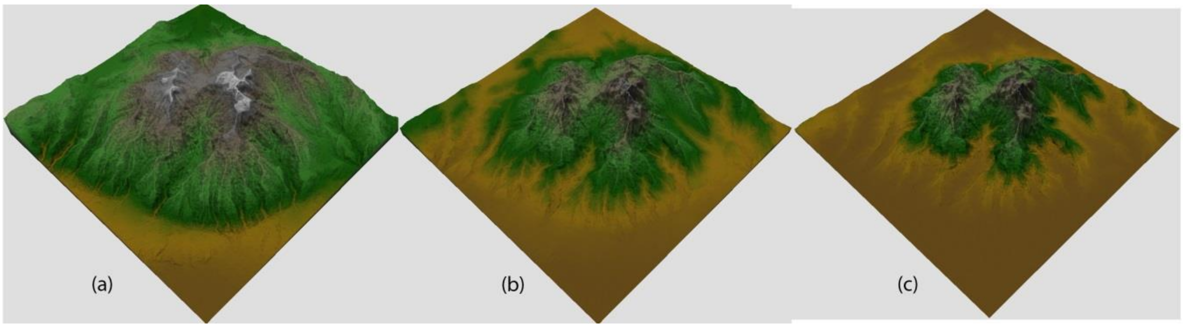

Figure 6. Glacial erosion stages (b and (c) of the basic model (a)

Thus the next stage involved the import of the Olympus' height map in a game engine and particularly in Unreal Engine's virtual environment, in order to explore more abstract variations of the mountain's relief.

Design Variations in Virtual Reality

The first attempt to implement a virtual reality version of Olympus in Unreal Engine, involved the use of a simple material and the engine's inherent wireframe option for materials. In Figure 7 you can see the result of the implementation. This solution is very simple and cannot provide any control to wireframe's properties such as grid cell size or shape.

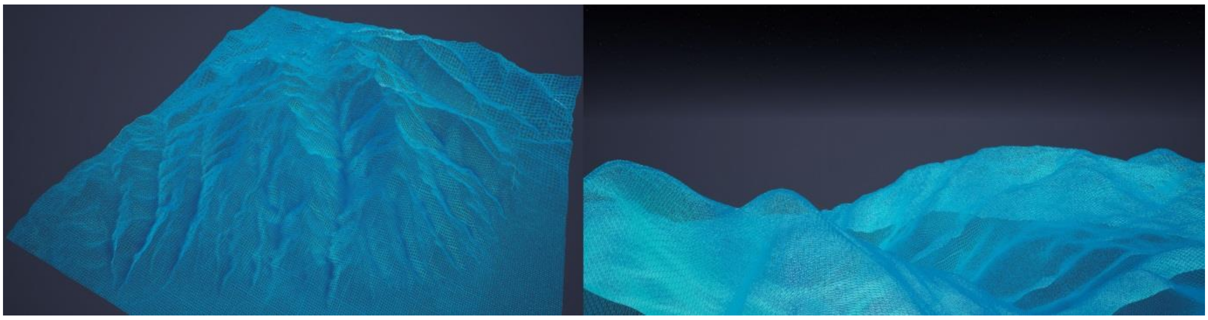

Figure 7. Implementation of Olympus relief in VR environment with the use of a wireframe material

The next attempt involved the creation of a grid material with the ability to control the cell size. For this reason the engine's blueprint visual scripting system was used. In Figure 8, the first version of this material is presented and the visual script that implements it, is described in Figure 9. The two main parameters were the grid cell scale and the intensity of the emitted color of the grid.

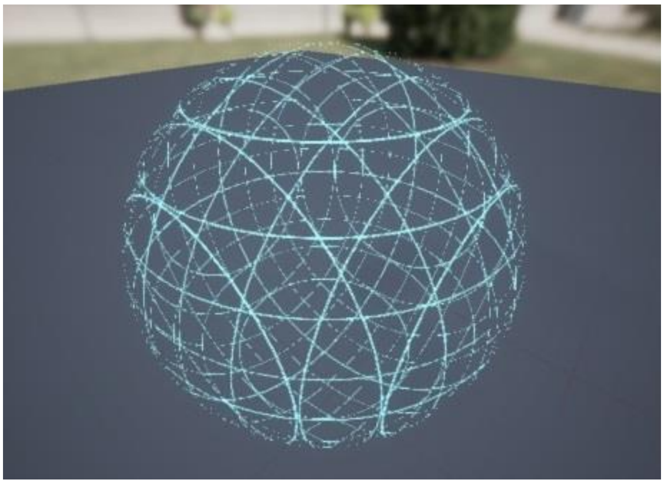

Figure 8. The first version of the grid material

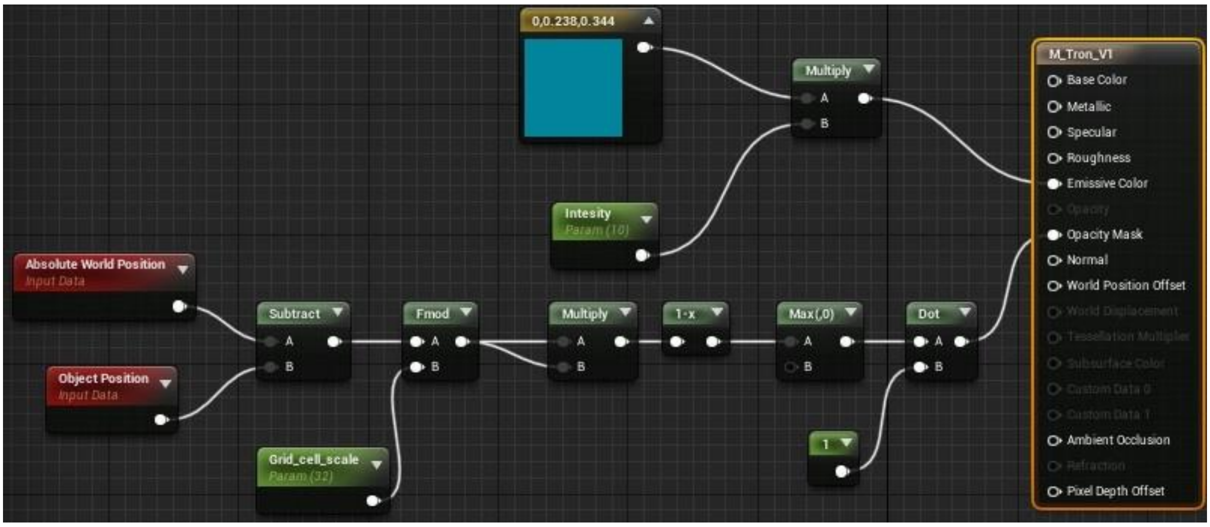

Figure 9.

The grid lines of this material were too thin and thus the far view of the mountain that can be seen in Figure 10 is abstract. Although that this grid cell scale parameterization provided an interesting visual result, other versions of the grid could and should be explored.

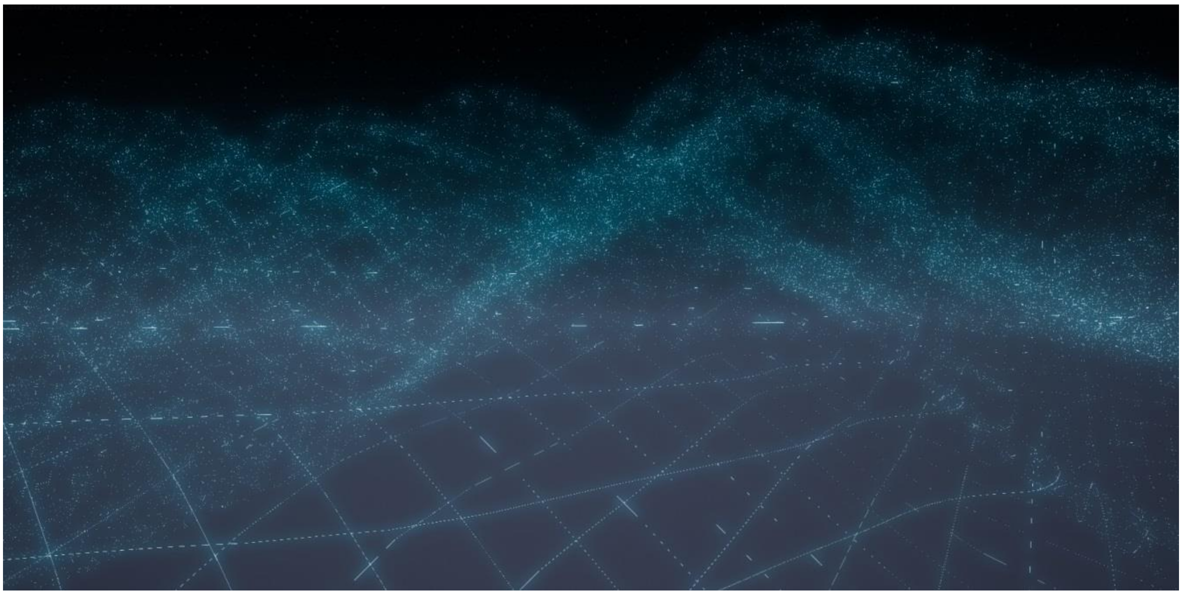
Figure 10.

In order to achieve a more definite result, a parameter that controls the grid line thickness was used in the implementation of the material which is presented in Figure 11. The algorithm that creates this grid, can be seen in Figure 12.

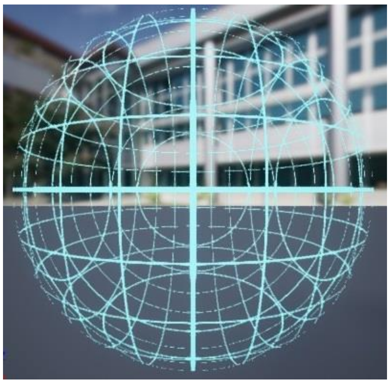
Figure 11.

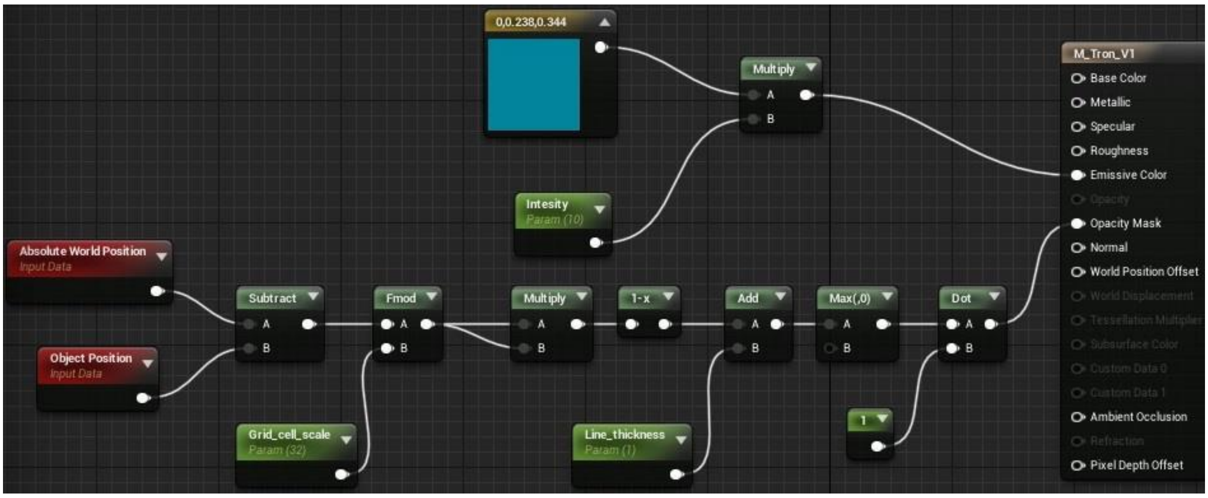

Figure 12.

Figure 13 depicts a close view of the material grid that implements this version of the relief. The values of the parameters of this material are presented in Figure 14. With this material the Olympus' morphological features are more properly defined.

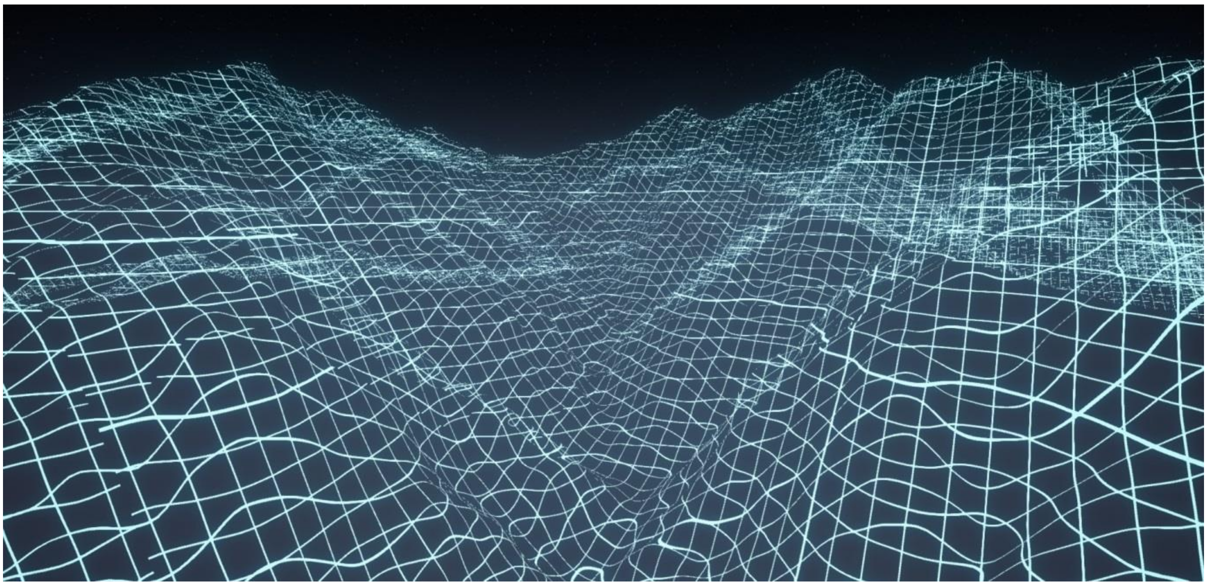

Figure 13.

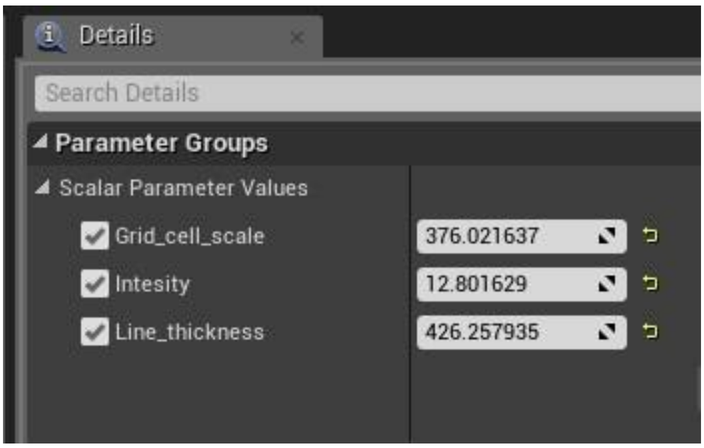

Figure 14.

In order to explore other possible representational variations of the relief, another approach was implemented. A new material was created by using the algorithm that is presented in Figure 15. The parameters of this implementation control the color, the amount of color glow and the edges of the grid cell. This allows the creation of different cell types of a grid that can be visible from greater distance.

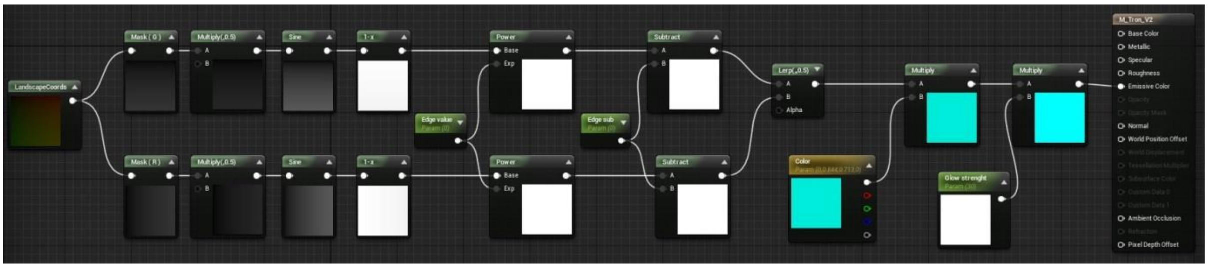

Figure 15.

In Figure 16 the reliefs that are produced by the use of two instances of this material are presented. The material parameters that create these reliefs are presented in Figure 17.

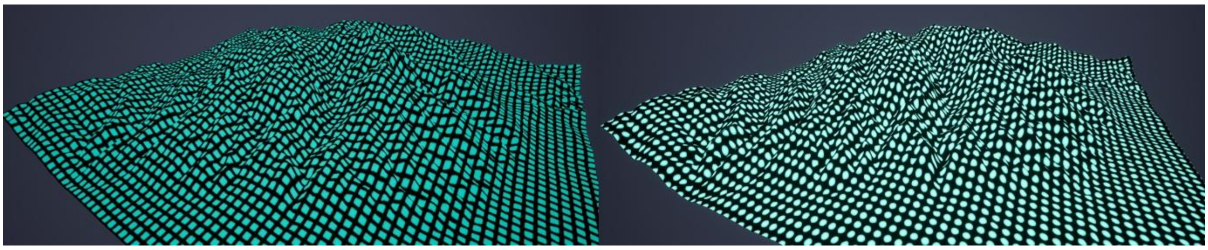

Figure 16.

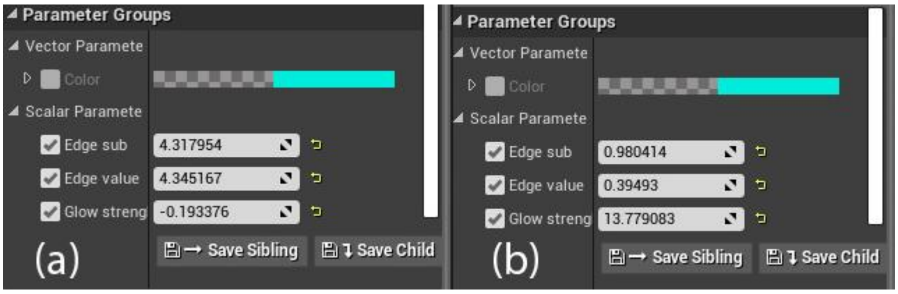

Figure 17. Material parameter values. Square grid (a) and circular grid (b)

As mentioned before, the implementation of realistic versions of the Olympus' geo-environment as well as the representational metaphors that the virtual variations of the mountain can provide, are both included in the field of the research and constitute interesting examples for further investigation. Thus, the next design approach involved the creation of surface materials which incorporate various morphological characteristics of the mountain, such as the contour lines of the relief (Figure 18), slopes with certain orientation (Figure 19) or the hydrological network (Figure 20). These materials were implemented by using the basic material node of Unreal engine, a multiply function that enhances color and processed height maps as texture samples.

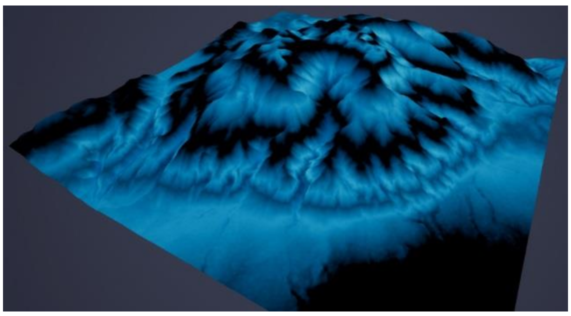

Figure 18.

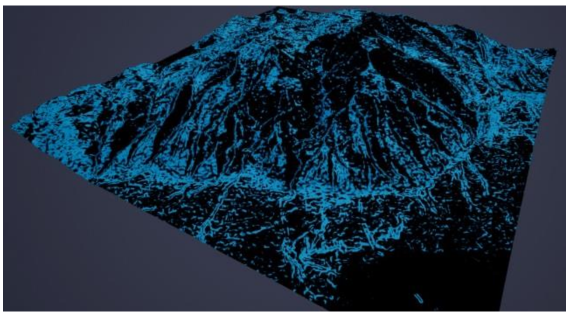

Figure 19.

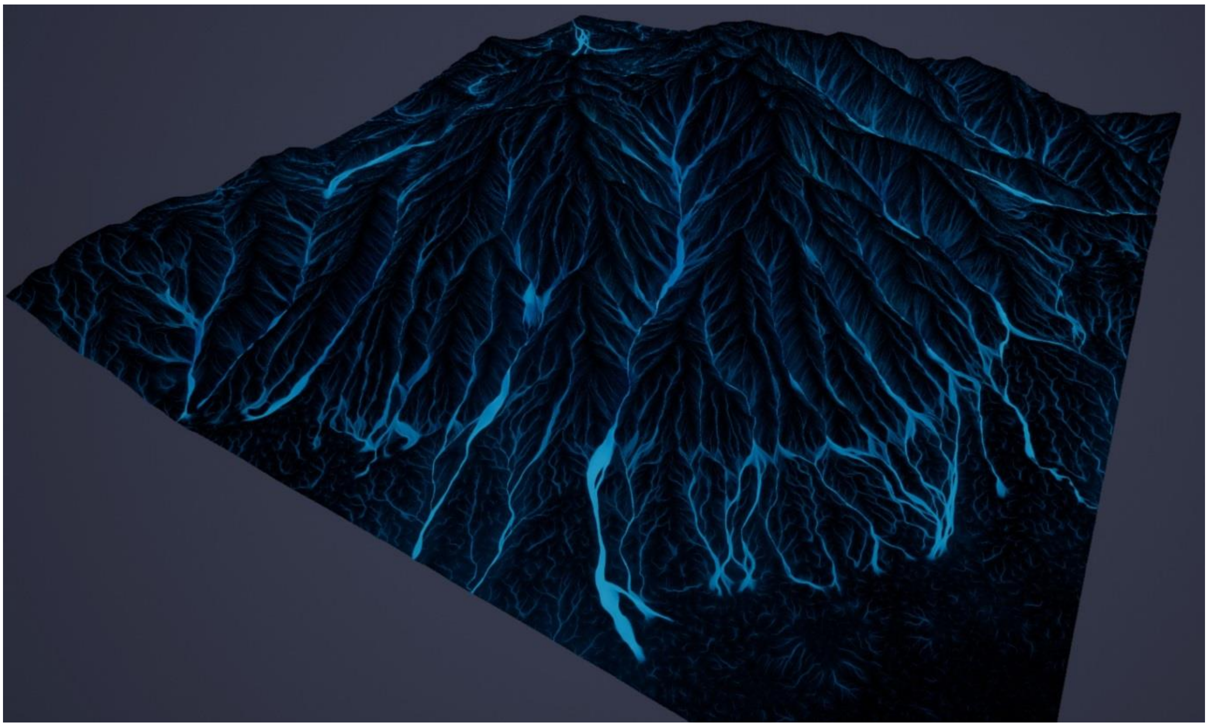

Figure 20.

Conclusion

The design approach that was described, involved the usage of game engines and other supplementary software in order to understand, conceptualize and design digital variations of the Olympian relief. The geomorphological examples that were introduced are able to provide visual simulations of the mountain that are accurate enough for use in various types of simulations. Furthermore, the virtual variations that were presented, represent an early attempt not to emulate the exact mountain Olympus, but rather to compose a landscape capable of providing tours and walkthroughs, narrations and authentic spatial experience of a “parallel”, virtual Olympus. The dynamic of such an experience is not defined exclusively by the spatial representation of the landscape but expands through the involvement and the real time interaction of the user in a virtual, hybrid geography. For this reason, further research is needed in order to reveal other important design and conceptual elements of the final synthesis and to allow the comprehension of the necessary processes that lead to an immersive, multimodal, digital environment.

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Moddb https://www.moddb.com/engines

ASTER http://asterweb.jpl.nasa.gov/gdem.asp

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