COMPARISON OF RENDERING PROCESSES ON 3D MODEL

Filip Popovski[1], Nikola Spasov[1], Svetlana Mijakovska[1]and
Gorica Popovska Nalevska[2]

[1]Faculty of Technical Sciences, SS KlimentOhridski, MakedonskaFalanga 34,
7000 Bitola, R. Macedonia
[2]International Slavic University Gavrilo RomanovicDerzavin,
7000 Bitola, R. Macedonia

ABSTRACT

Creating 3D vehicle model is complex process that requires basic knowledge of polygonal modeling. In this research, environment map is used as lighting with HDRI image.The final process of converting 3D scene to 2D image is called rendering. Image data will be obtained in four ways with various toolsets used in 3ds Max. They are: Scaneline, V-Ray, Mental Ray and Corona Renderer. At final step was made critical analysis on all of these techniques on the same computer system and excellent results were obtained.

KEYWORDS

Modeling, Real Time Rendering, Computer design, 3d Software, 3ds Max

1. INTRODUCTION

Nowadays, the 3D digitization of buildings and vehicled is extensively used in the fields of Architecture, Engineering and Construction (AEC).This has led to the development of multiple robotic platforms for the digitization of buildings and vehicles in recent years [1].Nevertheless, the point cloud models that are generated are almost exclusively used to evaluate the geometric features of them [2][3][4][5].Graphic systems are getting better, faster and cheaper at a bewildering rate and many new techniques are emerging each year from researchers and practitioners around the world, but the underlying principles and approaches constitute a stable and coherent body of knowledge [6]. This scientific paper will explain the creation of 3D vehicle model in 3ds Max and realistic rendering scenes. The process of creating 3D vehicle model contains the following: creating polygons and modifying them in order to get the shape of 3D model, reference images will be used for accurate dimensions, 3D model will be obtained, materials will be created and values will be entered for lighting (in this example the lighting will be obtained from an HDRI image). Camera option will be set and finally a method of rendering is selected, values are imported and a picture is obtained.

Time required for obtaining a rendering process depends on how complex our model is and what computer system we use, because it receives the image by performing mathematical calculations. It is best for the model to contain as few polygons as possible so we will have a shorter rendering time.

2. CREATING 3D MODEL OF A VEHICLE

The process of recovering 3D structure from 2D images has been a central endeavour within computer vision and the process of rendering such recovered structures is a subject of receiving increased interest in computer graphics [7]. Creating 3D model of a vehicle is a complex process that requires basic knowledge of polygonal modeling. Before starting modeling a vehicle, it is necessary to place reference images (Figure 1) of model that contains the actual dimensions of vehicle in order to obtain a real model. They are placed in a scene with three views: front, side and view from above. In this way we will have a look at the model from all sides and create all the standard items, such as 3D shapes, primitive spheres, lights and cameras. [8]
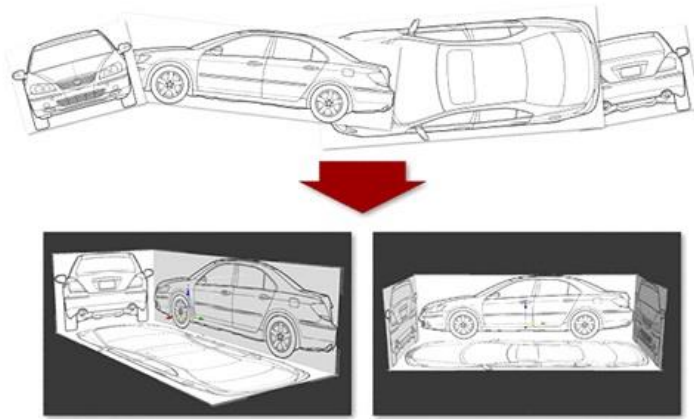

Figure1. Reference images of vehicle

Once the reference images are set, we can start with modeling process and creating the first polygon. By selecting a single view together with a reference image, we can start the process of creating a 3D model. By creating polygons, we begin to get the shape of a vehicle and we need to observe it from the three points of views of the reference images so that there will be no deformations of our model (Figure 2).
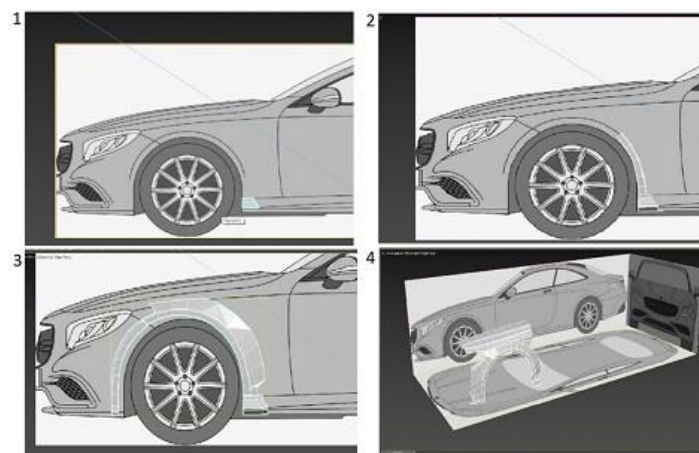

Figure 2. Beginning of modeling from polygons

Only half of the vehicle model should be created. The second half is created symmetrically using the symmetry modifier (Figure 3).
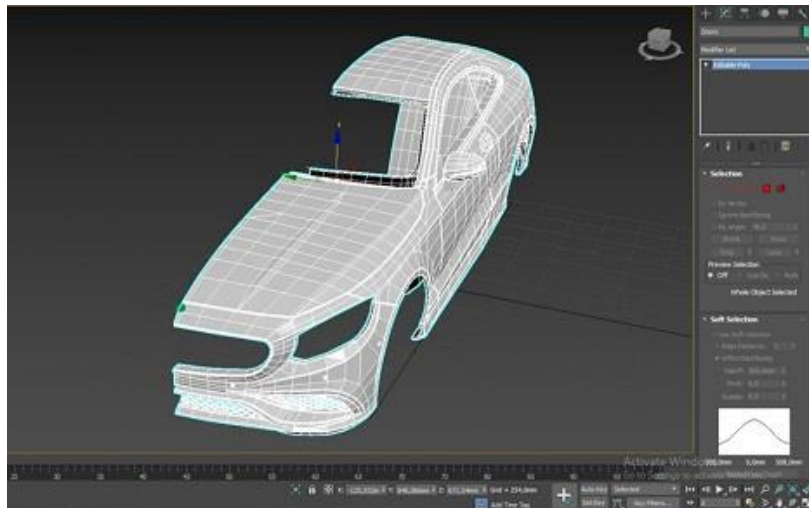
Figure 3. Symmetry modifier

When we finish the modeling process, the model will contain a large number of polygons, but its shape will not be very smooth. That's why we used TurboSmooth modifier (Figure 4). This modifier mathematically adds polygons between already made polygons and reduces the curvature between them. This is very important because rendering requires a huge number of calculations, which require a powerful configuration of the computer system.
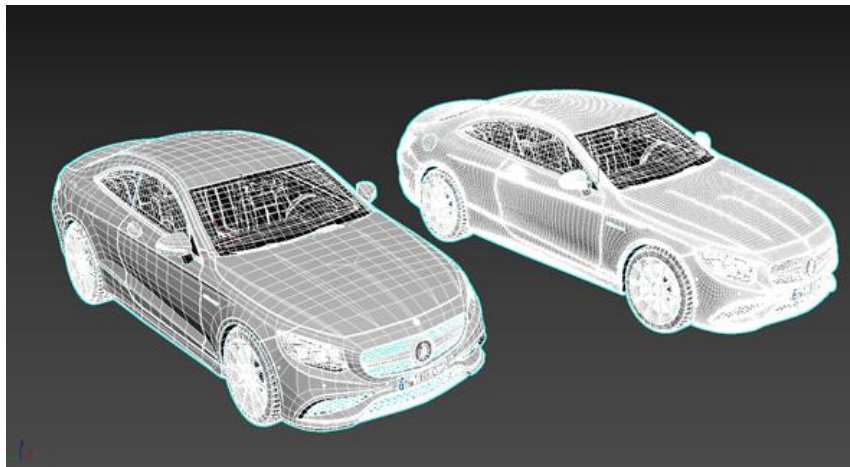

Figure 4. Left model without TurboSmooth modifier (fewer polygons), right model with TurboSmooth modifier (more polygons)

3. SCENE LIGHTING

In this research, environment map is used as lighting. It's a 360^0 degree HDRI image. If we want to make changes with the lighting of the image, we must transfer it to Material Editor where we can manage lighting values and placement in the space (Figure 5).
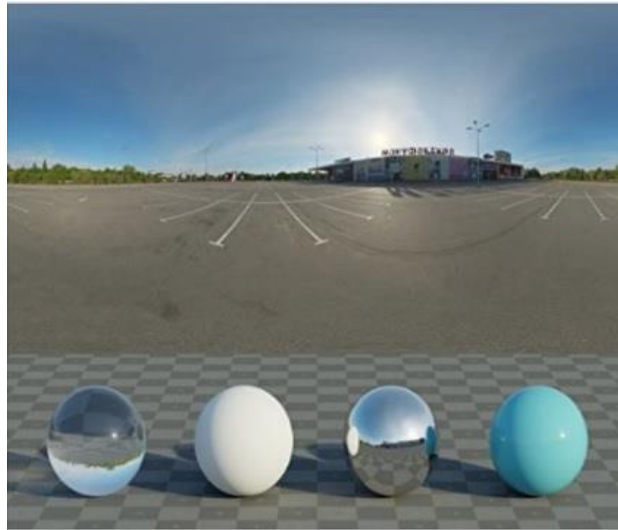
Figure 5. HDRI map used in the scene

4. RENDERING

The final process of converting 3D scene to 2D image is called rendering. It is process that turns 3D model into a 2D image that simulates light rays. Data contained in the scene file transferred to the rendering program is processed to obtain a digital image or a raster graphic image. Rendering is one of the main themes of 3D computer graphics. In graphic design, this is the last step, which gives the latest look of the models and the animation.

The theoretical concept of rendering is presented in the given equation, which serves for a more formal expression of the non-conceptual aspect of rendering. [9]

$$L_o(x,\vec{w}) = L_e(x,\vec{w}) + \int \Omega\, f_r(x,\vec{w},\vec{w}) L_i(x,\vec{w})(\vec{w}\cdot\vec{n})d\vec{w}$$

Here the output light Lo is a sum of emitted light Le and reflected light. Reflected light is the sum of incoming light Li from all directions multiplied by the reflection of the surface and the input angles, x is location of the space, w is direction of the light and ʃr is a function for distribution of two way reflection. Complete algorithms can be considered as a solution for specific formulations of this equation.
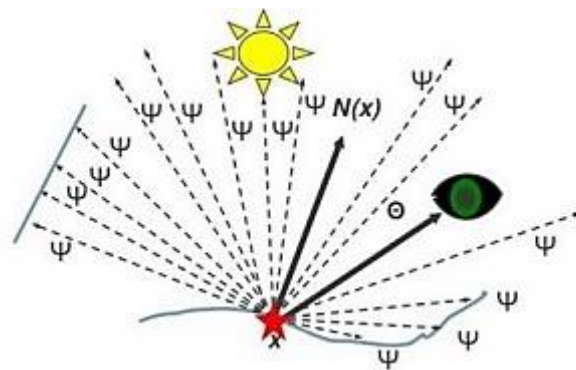

Figure 6. Rendering vectors shown in equation

Ray Casting technique uses surface-cutting beam tests to solve various problems in computer graphics and computer geometry. The scene seen from a particular perspective calculates the observed image based only on geometry and basic optical laws of reflection and perhaps with the use of Monte Carlo techniques to reduce the artefacts. [10]

Ray Tracing is a technique for generating an image by tracking the path of light through pixels in the image plane, simulating the effects of their encounters with virtual objects.

Radiosity is a method based on detailed analysis of light reflections on diffused surfaces. Images obtained from rendering are characterized by soft gradual shadows.

5. RENDERING AND SIMULATION TOOLSETS

In this research we will compare four rendering toolsets that work with 3ds Max. They are Scan line, V-Ray, Mental Ray and Corona Renderer. Each of them works differently to get the 3D generated image and has a different final result. For each of them a render will be presented as well as the results of the process.

The process of rendering is performed on a computer with the following specifications:

- 2 x Xeon X5650 2.66 GHz Processors
- 24 GB RAM
- 1050ti Nvidia graphics card with 4 GB of memory
- 512 MB SSD hard drive for faster program operation.

Scaneline

Scaneline is a standard rendering toolset for 3ds Max. This toolset calculates the scene as series of horizontal lines. It is harder to get realistic results when using an HDRI map as a lighting map. This is the most noticeable in the shadows of the car and its reflections. Therefore, this toolset is mostly used in simple scenes where too much realism is not needed.
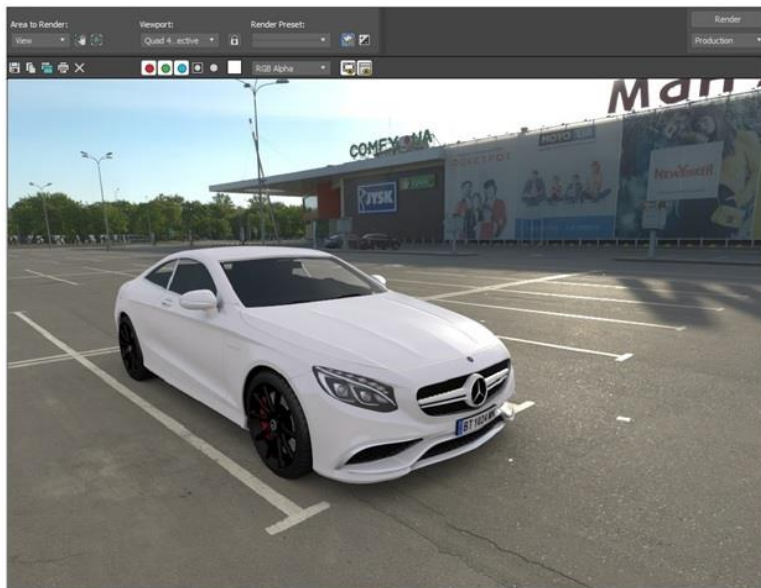

Figure 7. 3D generated image obtained with Scaneline toolset

There are 448279 vertexes and 795042 polygons in the scene. From 24 GB RAM available, the program used an average of 6.3 GB RAM and time for rendering was 41 minutes and 34 seconds.
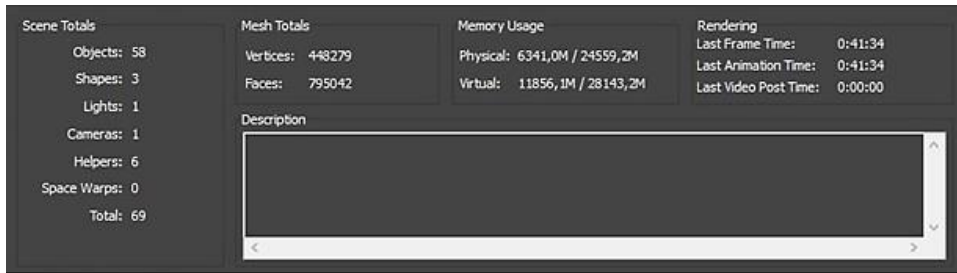

Figure 8. Data obtained with Scanline toolse

V-Ray

V-Ray is a rendering toolset for 3D programs that uses global lighting algorithms, including path tracking, photon mapping, radiation maps and directly calculated global lighting. The results obtained with V-Ray rendering toolset have an excellent quality and high degree of reality.
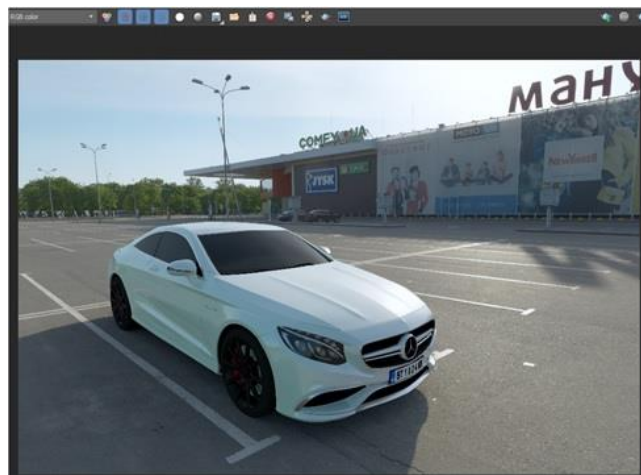

Figure 9. 3D generated image obtained with V-Ray toolset

There are 445024 vertexes and 788205 polygons in the scene. From 24 GB RAM available on the computer, the program used an average of 7.3 GB RAM. Rendering time was 17 minutes and 56 seconds, which is the fastest time from all of these four rendering toolsets. All of this is due to the improvement of V-Ray rendering toolset, like using memory of graphic card and also algorithms for calculating the light are quite advanced.
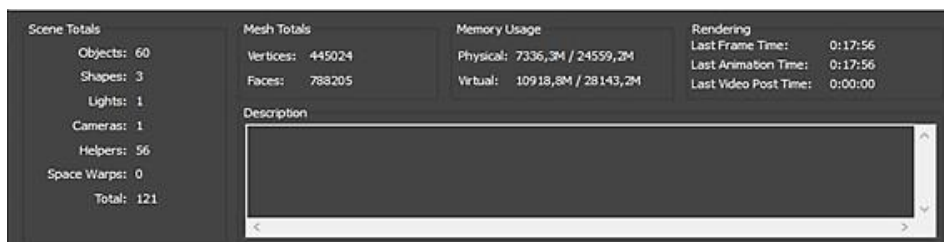

Figure 10. Data obtained with V-Ray toolset

24

Mental ray

Mental Ray is rendering toolset for quality production. It supports beam tracking for image generation. Mental Ray has been used in many feature films, including Hulk, The Matrix, Star Wars, Poseidon and many more. The primary feature of Mental Ray is achieving high performance through parallelism and working on a project through multiple connected computers.
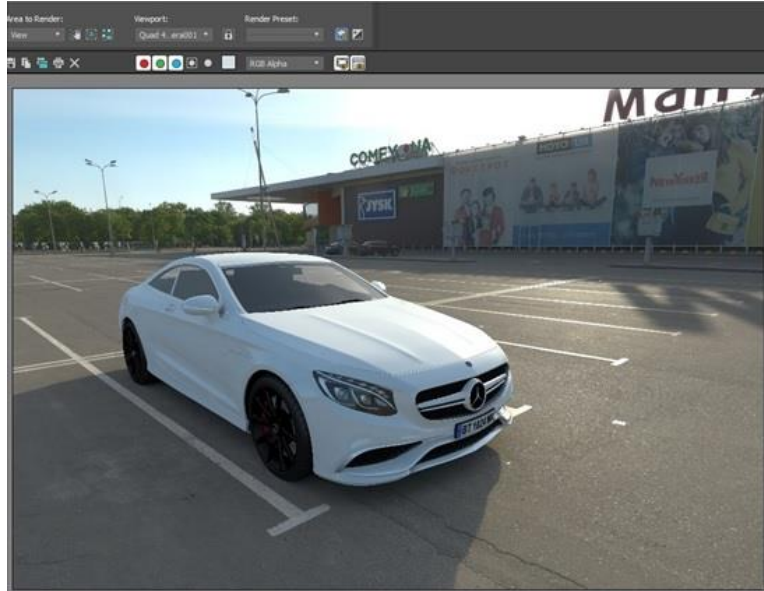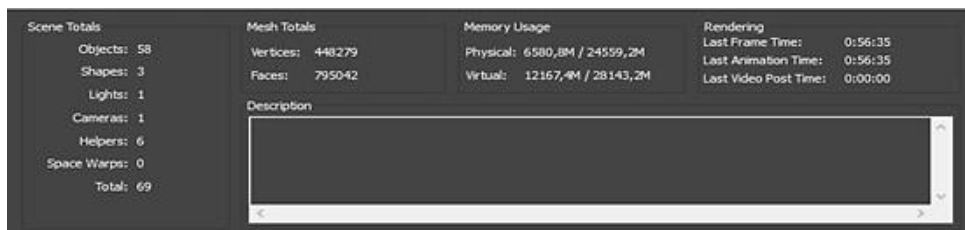

Figure 11. 3D generated image obtained with Mental Ray toolset

There are 448279 vertexes and 795042 polygons in the scene. From 24 GB RAM available on the computer, the program used an average of 6.5 GB RAM. Rendering time was 56 minutes and 35 seconds. The results from lighting of HDRI map are excellent and high quality realism is achieved. Standard materials of 3ds Max program are used which required more setup time.

Figure 12. Data obtained with Mental Ray toolset

Corona Renderer

Corona Renderer is modern high-performance photorealistic rendering toolset available for 3ds Max. The most attractive feature of the Corona Renderer is the interactive rendering. This allows the user to change the settings instantly in real time and to show how changes have effected the scene. In fact, all of this can be done in real time during the rendering process.
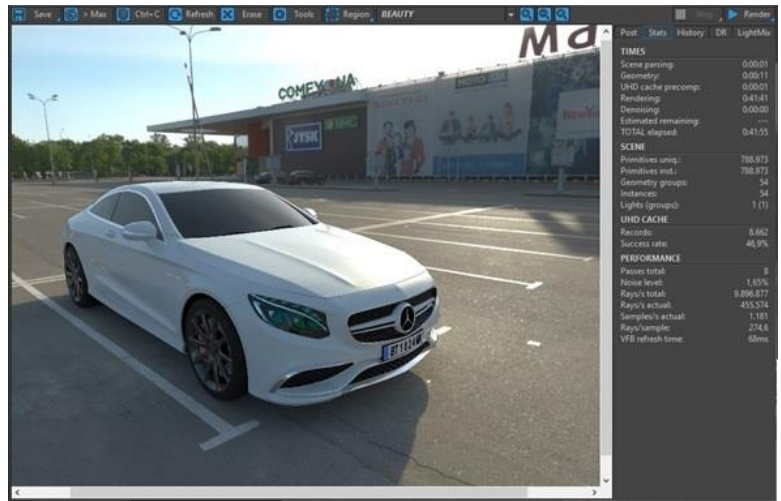
Figure 13. 3D generated image obtained with Corona Renderer

There are 444802 vertexes and 787804 polygons in the scene. From 24 GB RAM available from the computer, the program used an average of 6.3 GB RAM. Rendering time was 41 minutes and 58 seconds. Lighting and reflections have a great result and a high degree of realism. The good thing about using this toolset is use of a library of materials like V-Ray toolset, which significantly reduces the time required to prepare the scene.
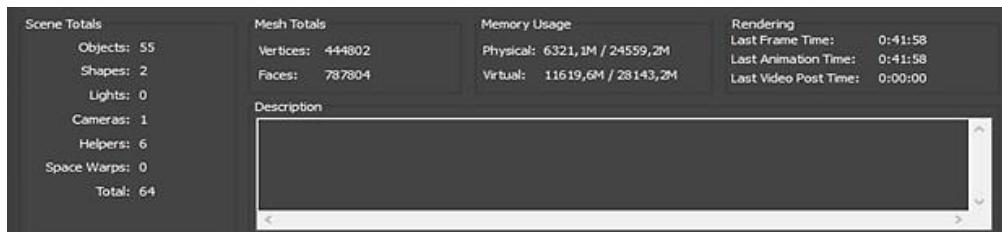

Figure 14. Data obtained with Corona Renderer

6. RESULTS AND ANALYSIS

In this research, in the application of 3ds Max were used V-Ray, Mental Ray, Scaneline and Corona Renderer. The rendering process was working on a computer system with 2 x Intel Xeon processors with 24GB RAM and Nvidia graphics card with 4GB RAM. Each of the toolsets works on a separate principle and gives a different rendering result. Best rendering result we have with V-Ray because rendering quality and time was excellent. Mental Ray and Corona Renderer give us fantastic results for the lighting and realism of the scene but have longer rendering time.Weaker results were achieved when using the Scanline rendering in which the realism of the scene was on low level.

Table 1. Comparing performance and times of rendering with different toolsets

	Scaneline	V-Ray	Mental Ray	Corona Renderer
Processor	2 x Intel Xeon processor X5650 2,66 GHz 24GB RAM 1050ti Nvidia graphic card with 4GB RAM 512MB SSD			
Vertex	448279	445024	448279	448802
Polygons	795042	788205	795042	787804
Used RAM	6,3	7,3	6,5	6,3
Rendering Time	41m 31s	17m 56s	56m 35s	41m 58s
Rendering Quality	Low	High	High	High

7. CONCLUSIONS

3ds Max is a powerful computer program specifically designed to help 3D artists, architects, engineers and designers in a variety of disciplines to implement their projects. Modeling vehicle with 3ds Max is a complex task and for this reason, the most important step is to place reference images from at least two views. The modeling process cannot be imagined without the knowledge of working with polygons or editing polygons and understanding how the turbo smooth modifier works. Adding more details to the interior of the vehicle makes the final image more realistic.

Final rendering process requires a lot of testing and for this purpose it is recommended that the resolution and image quality is minimized. A good starting point for the materials is the V-Ray Material Presets Pro. This toolset contains many types of materials and the desired results can be obtained by simply editing the specifications of these materials. One of the easiest and fastest ways to illuminate light scenes is to use a short HDRI with a high dynamic range. This technique makes the scene look like it's being shown in the same place in real life. Camera settings are important to get the right lighting model.

There are several rendering toolsets and results show that the best solution is to use V-Ray when we want a shorter rendering time. While for rendering large scenes, we need to use Mental Ray. Corona Renderer gives excellent results but has a long rendering time. Scaneline Rendering is used only for primitive scenes.

REFERENCES

[1] Adán, A.; Quintana, B.; Prieto, (2019), S.A. Autonomous mobile scanning systems for the digitization of buildings: A review. Remote Sens. 2019, 11, 306, doi:10.3390/rs11030306

[2] Valero, E.; Adan, A.; Huber, D.; Cerrada, C. Detection, (2011),Modeling and Classification of Moldings for Automated Reverse Engineering of Buildings from 3D Data. In Proceedings of the 28th International Symposium on Automation and Robotics in Construction (ISARC), Seoul, Korea, 29 June–2 July 2011; doi:10.22260/ISARC2011/0099.

[3] Quintana, B.; Prieto, S.A.; Adán, A.; Vázquez, A.S. (2016), Semantic Scan Planning for Indoor Structural Elements of Buildings. Adv. Eng. Inform. 2016, 30, 643–659, doi:10.1016/j.aei.2016.08.003.

[4]   Macher, H.; Landes, T.; Grussenmeyer, P. (2017), From point clouds to building information models: 3D semi-automatic reconstruction of indoors of existing buildings. Appl. Sci. 2017, 7, 1030, doi:10.3390/app7101030.

[5]   Wang, Q.; Kim, M.K. (2019), Applications of 3D point cloud data in the construction industry: A fifteen-year review from 2004 to 2018. Adv. Eng. Inform. 2019, 39, 306–319, doi:10.1016/j.aei.2019.02.007.

[6]   Hill F. (2000), Computer Graphics Using Open GL (2nd Edition), Prentice Hall

[7]   Debevec P. (1996), Modeling and Rendering architecture from Photographs, University of California

[8]   Kelly L. Murdock (2014), Autodesk 3ds Max Bible.

[9]   Kajiya, J., (1986), The rendering equation.

[10]   Woop S., Schmittler J., Slusallek P., (2005), "RPU: A Programmable Ray Processing Unit for Realtime Ray Tracing", Siggraph.

AUTHORS

Prof. Filip Popovski is a Doctor of Technical Sciences in Graphic Engineering at Faculty of Technical Sciences in Bitola, Macedonia. He is interested in computer graphics, visualization, 3d Virtual reality.

Nikola Spasov is graphic engineer at Faculty of Technical Sciences in Bitola, Macedonia. He is interested in computer graphics, visualization, 3d Virtual reality.

Prof. Svetlana Mijakovska is a Doctor of Technical Sciences in Graphic Engineering at Faculty of Technical Sciences in Bitola, Macedonia. She is interested in computer graphics, visualization, 3d Virtual reality.

Prof. Gorica Popovska Nalevska is a Doctor of pedagogy at International Slavic University Gavrilo Romanovic Derzavin in Bitola, Macedonia.