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The impact of computer component and lighting performance on the speed and quality of the generated image

KEYWORDS

blender, Cycles, EEVEE, light bounces, graphics engines

ABSTRACT

One of the most common and popular programs for creating 3D graphics is the free and still under development Blender software. It has two main scene rendering engines - "Cycles" and "EEVEE"; both offer different effects and meet different user needs. The main features of each are mainly greater realism when producing scenes in Cycles, accuracy in light reflections and attention to volumetric effects. EEVEE, unlike its predecessor, is not physically correct, it shows the image in real time, so it generates scenes incredibly fast, but never realistic. In this article, a comparative study of the speed of the two rendering engines was carried out according to different workstations with other hardware components. For this, a simple scene with several light sources was built and a number of renders were made.

1. INTRODUCTION

The origins of computer graphics date back to the early 1960s. The first graphic representations were limited to the use of line and curve, and objects were represented in the form of planes giving the illusion of a three-dimensional object. This type of graphics is called vector graphics and is considered the forerunner of 3D graphics [1]. Three-dimensional graphics is defined as the use of three-dimensional geometric data (usually through Cartesian coordinates) to perform computations, i.e., shape shifting, animation, collision detection, but also to create 2D images suitable for display on a standard computer screen or monitor. This process is called rendering, it is the transformation of 3D data into 2D images [2].

Rendering of modern models is based on the use of specialized software that allows to show various graphic effects on the created scene, including reflections, shadows, refractions, or volumetric effects. These effects ultimately affect the color of the pixel generated, by the graphics processor. The state of three-dimensional objects depends on the geometry, textures, viewpoint, lighting, and other content used [3]. Reflection simulation is the most important part of the perception of the generated scene. Its increasing sophistication over the last two decades has dramatically affected the photorealistic perception of the quality of generated images [4]. Early algorithms considered only local illumination, which over time has been expanded to include global illumination, surface reflections and shadows.

The global illumination effect is a model of illumination in three-dimensional graphics that relies on the illumination of every object in the scene by both light-emitting sources and light reflected from other objects. It can greatly improve the understanding of the volume structure and spatial relationships of objects. In order to maximize the achieved photorealistic effect, the number of allowed reflected light vectors should be increased. However, the use of global illumination carries a high use of computing power due to the high number of algorithms required for processing [5]. Especially in the case of lighting and shadows, it is difficult to achieve a balance between quality and efficiency of image generation [6]. Modern graphics engines involve high use of computer resources, requiring more powerful graphics cards, processors, more RAM and more powerful disks [7].

The subject of our article's research is the effect of the performance of computer components and the lighting used in the scene on the speed and quality of the generated image, based on the open-source software Blender [8]. The choice of software was justified by the results of Hendriyani and Amrizal's qualitative study of the generated image, comparing the most popular 3D modeling program – 3Ds Max with the free Blender [9]. The selected software allows you to work in two, basic modes – local lighting, which is a real-time preview of the scene being created, and global lighting, which allows for the highest quality render. The level of complexity of the scene can significantly affect the time to obtain the result in the form of an image [10]. The most popular graphics engines used in Blender – EEVEE and Cycles -are equipped with GPU acceleration algorithms, allowing a significant reduction in image rendering time without a noticeable change in image quality [11].

2. METHODS AND MATERIALS

For the purpose of the study, a scene (Fig. 1) was created in Blender consisting of an enclosed room- a cuboid -in which three 3D solids were placed. The first is a sphere obtained by transforming the UV of a sphere with an edge smoothing modifier. A basic texture with reflective (specular) properties was applied to it. The second object is a cube with a matte texture – a surface that absorbs light. The last solid placed in the studied scene is a cylinder with the property of transparency, a glass texture simulation was used, causing reflection with the simultaneous passage of vectors of projected light through the object. One zone light (area light), with the vector of generated light directed at the solids, and one spot light were placed in the studied room.

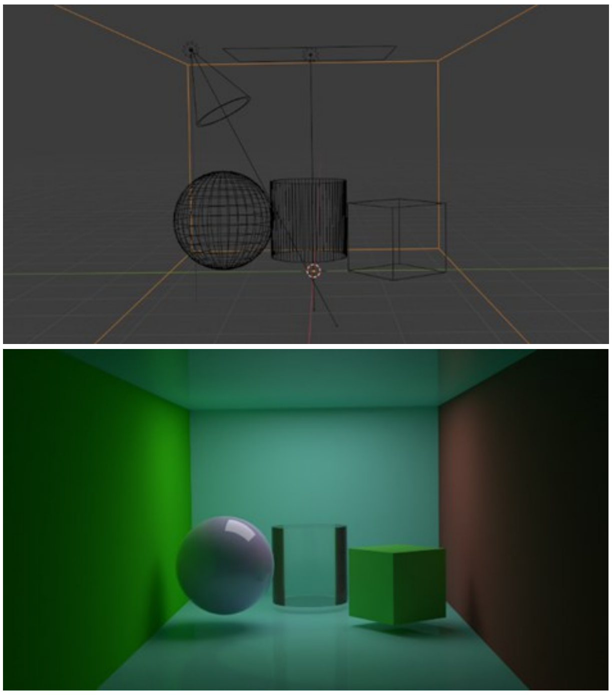

Figure 1. The studied scene made in Blender. On the top, a mesh view of the models with the X-Ray option running. On the bottom, a render made with the Cycles engine

The scene created in this way allowed us to study the effect of the computing power of the workstations (Tab. 1) on the obtained rendering time of the scene. Three devices with different hardware specifications were used for the measurements. The main differences in the components focused on the central computing units (processors), the amount and timing of the random access memory (RAM) and the graphics cards' dedicated VRAM (GPU).

Table 1. Hardwere specifications of the workstations used for scene renderig time measurements

	Workstation		
	1	*2*	*3*
CPU	Intel Core i5-7300HQ 4-Core 2.5GHz	Intel Core i5-7600K 4-Core 3.80GHz	AMD Ryzen 7 3700X 8-Core 3.60GHz
RAM Memory	8GB 2400MHz	16GB 2133MHz	16GB 3200MHz
GPU	GeForce GTX 1050 4GB	GeForce GTX 1050Ti 4GB	GeForce GTX 1060 6GB
Hard Drive	SSD	SSD	M2 SSD
Operating System	Windows 10 Home 64-bit	Windows 10 Home 64-bit	Windows 10 Home 64-bit

3. RESULTS

A. Cycles

The first graphics engine available in Blender to be explored is Cycles. It allows to determine the number of light reflections in a scene using rendering settings for different types of lighting and surfaces. Eight measurements were made of the scene's render time in the Cycles graphics engine, for a pre-imposed maximum of one light reflection, for each workstation specification (Fig. 2–4). Averages of the measurements were determined for comparison purposes. They are as follows: for workstation No. 1 – 88.08 seconds; for workstation No. 2 – 16.28 seconds; and for workstation No. 3 – 10.27 seconds. There is a noticeable decrease in the scene rendering time between workstation one and two - the decrease is nearly 81.5%. For the third workstation, the decrease in image generation time compared to station two is noticeably smaller – it is only about 36.9%.

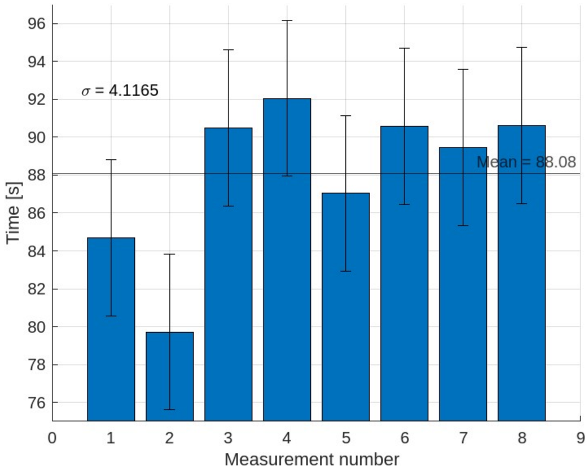

Figure 2. Measurements of scene rendering time in the Cycles graphics engine at 1 allowable reflection of light for workstation No. 1

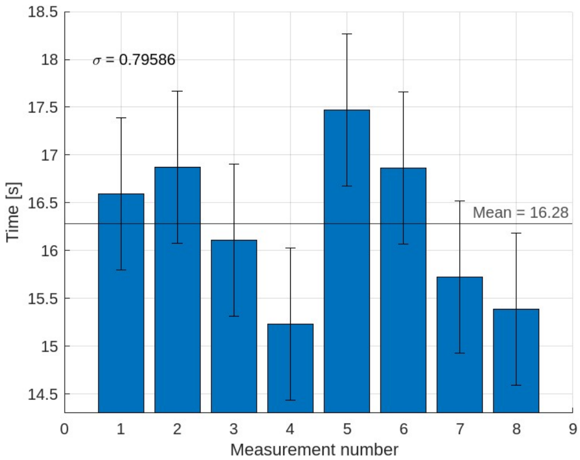

Figure 3. Measurements of scene rendering time in the Cycles graphics engine at 1 allowable reflection of light for workstation No. 2

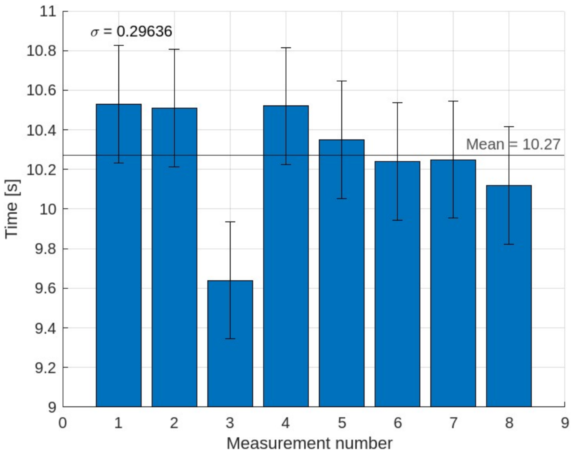

Figure 4. Measurements of scene rendering time in the Cycles graphics engine at 1 allowable reflection of light for workstation No. 3

The rendering times of the scene for the same graphics engine were examined sequentially, but with an increase in the reflection of light vectors to a maximum of six. In this case, the following average values of measured time were recorded for the measurements taken (Figs. 5–7): for workstation No. 1 – 134.27 seconds; for workstation No. 2 – 35.35 seconds; and for workstation No. 3 – 16.28 seconds. The decrease between the average time of image generation for the first device relative to the second is about 73.7%, while between the second and third – nearly 53.9%.

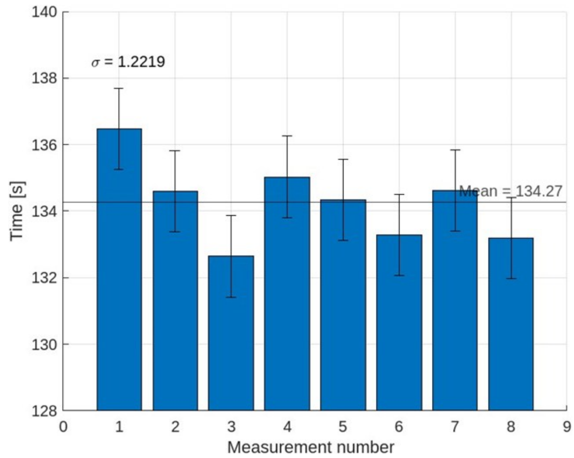

Figure 5. Measurements of scene rendering time in the Cycles graphics engine at 6 allowable reflection of light for workstation No. 1

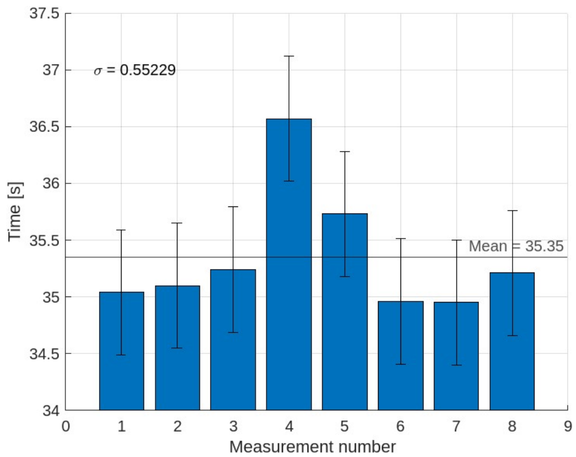

Figure 6. Measurements of scene rendering time in the Cycles graphics engine at 6 allowable reflection of light for workstation No. 2

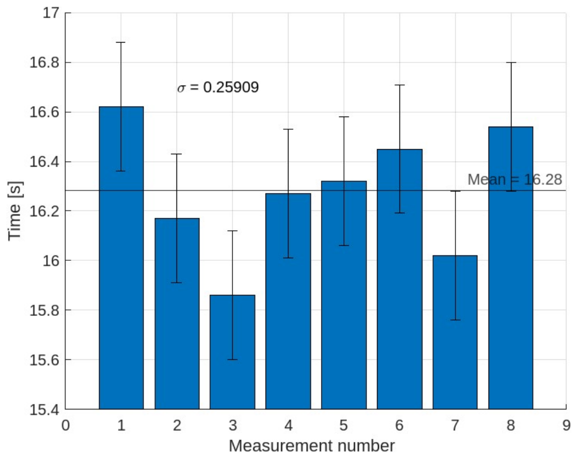

Figure 7. Measurements of scene rendering time in the Cycles graphics engine at 6 allowable reflection of light for workstation No. 3

The last measurements for the Cycles graphics engine are renders of the scene at the allowed maximum of twelve light reflections in the rendered image (Fig. 8–10). For these settings, the activity duration was the longest compared to the other measurements. This is related due to the larger number of vectors to be calculated. The average time from the eight measurements for each station is: for No. 1 – 140.97 seconds; for No. 2 – 41.93 seconds; and for No. 3 – 17.89 seconds. The decrease in the average time value between machine one and two is approximately 70.3%, and for machine two and three it is approximately 57.3%.

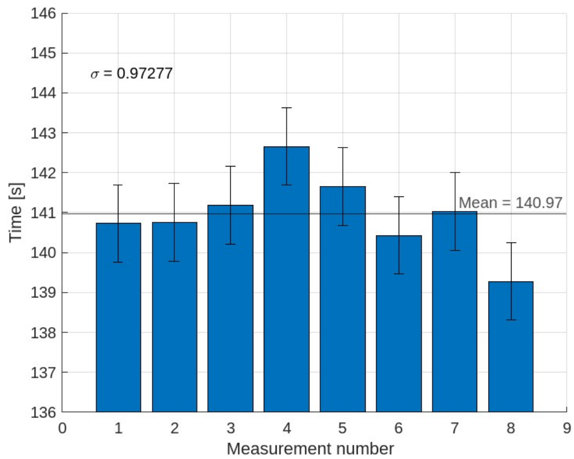

Figure 8. Measurements of scene rendering time in the Cycles graphics engine at 12 allowable reflection of light for workstation No. 1

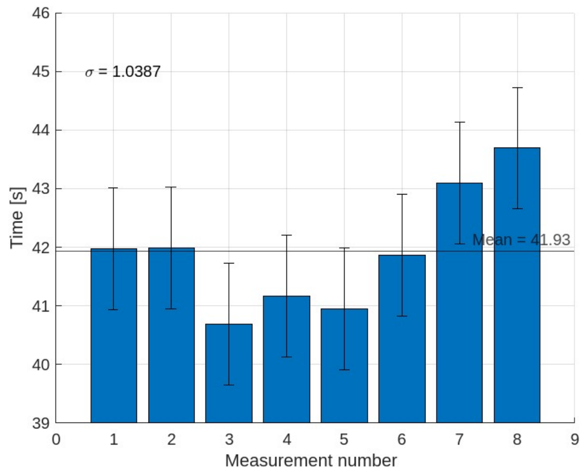

Figure 9. Measurements of scene rendering time in the Cycles graphics engine at 12 allowable reflection of light for workstation No. 2

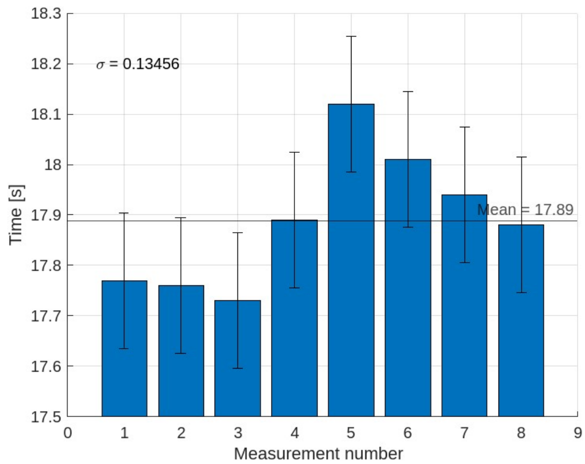

Figure 10. Measurements of scene rendering time in the Cycles graphics engine at 12 allowable reflection of light for workstation No. 3

B. EEVEE

The second graphics engine tested was EEVEE, an algorithmically and complexly simpler solution. This engine does not have as much photorealistic properties as the Cycles graphics engine. This is noticeable in the quality of the generated image and the overall degradation of the complexity of the lighting of the generated scene. This engine also prevents the possibility of blocking the maximum number of light vector reflections from the surface - hence only eight measurements were made for each workstation (Fig. 11–13). The following average values of measured time were obtained: for workstation No. 1- 1.44 seconds; for No. 2 – 1.03 seconds; and for No. 3 – 0.68 seconds. The decrease in time between the first and second stations is nearly 28.5%, and for the second and third stations approximately 34%.

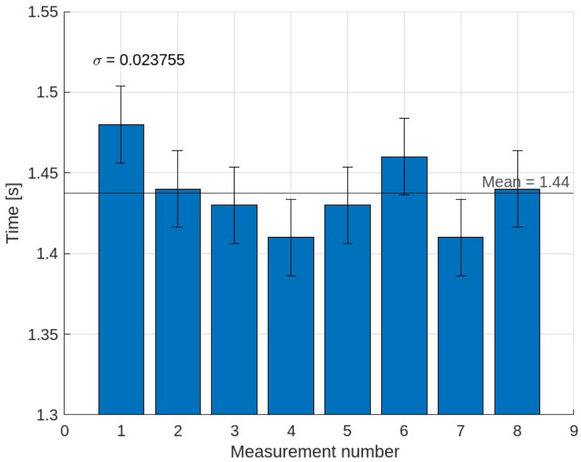

Figure 11. Measurements of scene rendering time in EEVEE graphics engine for workstation No. 1

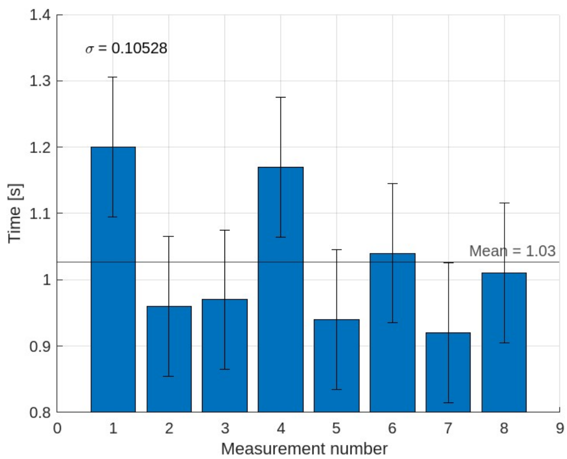

Figure 12. Measurements of scene rendering time in EEVEE graphics engine for workstation No. 2

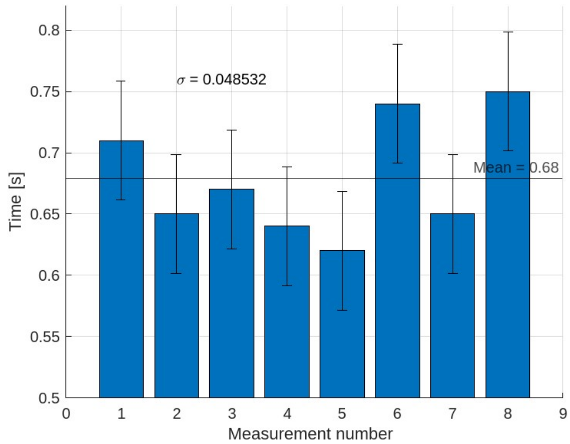

Figure 13. Measurements of scene rendering time in EEVEE graphics engine for workstation No. 3

C. Comparison statement – Cycles and EEVEE.

The average scene rendering time values obtained in the study vary significantly depending on the hardware specifications of the workstation, the graphics engine used, and the light propagation constraints in the scene. The biggest difference is noticeable when comparing graphics engines between Cycles and EEVEE (Fig. 14). The decrease exceeds up to 100% in this case, as the EEVEE engine takes about a second to create a scene, where the average times for Cycles range from 10 seconds for the fastest machine to as much as 140 seconds for the machine with the worst hardware parameters. This change in time has an obvious impact on the quality of the rendered image, which is better for the first of the tested engines and allows the so-called photorealism of the image to be achieved.

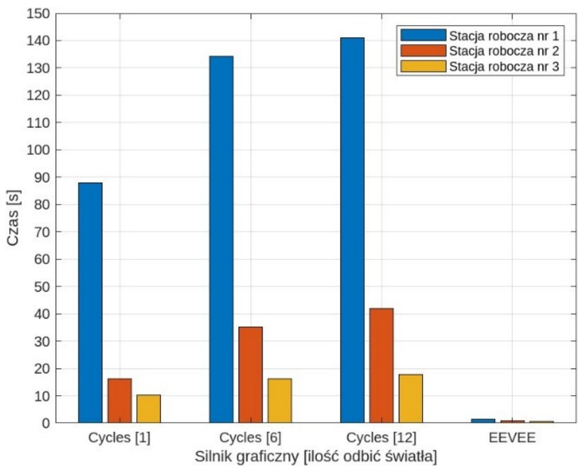

Figure 14. Summary of average measurement times for each workstation depending on the graphics engine

An interesting phenomenon that was observed when comparing the average measurement time value for the Cycles graphics engine is the decrease in the difference between workstations one and two. These are, respectively, for one, six and twelve light reflections: 81.5%; 73.7%; and 70.3%. The biggest jump was noticed when increasing the number of light reflections from one to six. As the number of reflections increases, the performance difference between these stations decreases. When comparing the hardware specifications of work-station No. 1 and 2, it can be seen that the main difference in the device's components is found in the processor clocking and the amount of RAM and its timing. From this, the increasingly slower decrease in value may also be due to the limitation of the identical number of processor threads, which is responsible for the number of calculations of new light vector positions that can be performed simultaneously.

On the other hand, for workstation No. 2 and 3, the decreases are respectively: 36.9%; 53.9% and 57.3%. Thus, there is a noticeable increase in the time difference between these stations as the number of reflections increases. This may be related to the difference in the number of cores in the central computing units, which occurs between station No. 2 and station No. 3. The doubled number of cores – from 4 to 8 – allows for an increase in simultaneously supported algorithms for calculating new positions of reflected light vectors, which has a significant impact on the rendering time of a lighting-complex scene.

In the EEVEE graphics engine, the difference in time drops between machines are pretty much identical. Scenes that are not lighting-complex are processed into images in incredibly fast time. So, it's hard to analyze the impact of computational components for such an environment.

CONCLUSION

The conducted research and its analysis led to the following conclusions:

- As the number of light reflections used in the scene increases, there is a slow decrease in the difference in image rendering time. The largest difference in time occurs when increasing the small values of light reflections.
- With more light reflections in the scene, the difference in image quality becomes imper-ceptibly low.
- The biggest impact on reducing the scene generation time comes from increasing the number of cores of the computing unit and the operating memory of the workstation.
- The resource-intensive Cycles graphics engine makes it possible to achieve a highly photo-realistic scene, in contrast to the fast and simple EEVEE engine.

It is worth noting that if you want to deal professionally or at least at a good level with the creation of photorealistic scenes in the 3D Blender environment, it is advisable to invest in high-quality computing equipment, i.e., multi-core CPU, fast RAM, and a computationally powerful GPU. scene.

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