Artificial intelligence in the context of photorealism in architectural visualization

Inteligencia artificial en el contexto del fotorrealismo en la visualización arquitectónica

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Abstract

This paper discusses the integration of artificial intelligence technology with architectural visualization. This research attempts to test the claim that in 2024, the integration of architectural visualization with artificial intelligence applications can create more realistic reference images for representative reference images than rendering programs. Images created with selected rendering engines and images created with artificial intelligence are compared and tabulated based on the scores given by architects to the specified criteria. According to the results, artificial intelligence is not yet able to render the given reference model at the expected level. Although artificial intelligence technology is still below expectations in this field, the results it gives in short periods of time can be useful from time to time. This research is important in terms of creating an environment for discussion on the potential advantages that artificial intelligence will bring to the field of architectural visualization and providing a perspective on this with the comparison made.

Keywords:

architectural visualization; artificial intelligence; render; photorealism; rendering engine

Resumen

Este artículo analiza la integración de la tecnología de inteligencia artificial con la visualización arquitectónica. Esta investigación intenta poner a prueba la afirmación de que, en 2024, la integración de la visualización arquitectónica con aplicaciones de inteligencia artificial puede crear imágenes de referencia más realistas para imágenes de referencia representativas que los programas de renderizado. Las imágenes creadas con motores de renderizado seleccionados y las creadas con inteligencia artificial se comparan y tabulan en función de las puntuaciones otorgadas por los arquitectos a los criterios especificados. Según los resultados, la inteligencia artificial aún no es capaz de renderizar el modelo de referencia dado al nivel esperado. Aunque la tecnología de inteligencia artificial está aún por debajo de las expectativas en este campo, los resultados que ofrece en cortos periodos de tiempo pueden ser útiles de vez en cuando. Esta investigación es importante para crear un entorno de debate sobre las posibles ventajas que la inteligencia artificial aportará al campo de la visualización arquitectónica y ofrecer una perspectiva al respecto con la comparación realizada.

Palabras Clave:

visualización arquitectónica; inteligencia artificial; renderizado; fotorrealismo; motor de renderizado

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1. Introduction

Today, the evolution of technology indirectly affects many fields. Architecture is one of the disciplines that has been greatly affected by this process, as the architectural profession benefits from the digital environment in many aspects. Technological advances bring a new dimension to architectural practices today. With the rapid advancement of technology, artificial intelligence and machine learning have been integrated into the design process, offering new opportunities and challenges for architects and designers (Ko, Ajibefun , Yan, 2023). The emergence of artificial intelligence[3] design tools is similar to digital modeling tools (e.g., AutoCAD and Rhino), which currently only serve as aids to traditional architectural design workflows (Li, P, Li, B., & Li, Z., 2024). However, combining architectural visualization with artificial intelligence reveals a potential beyond traditional methods. This research provides a perspective on the impact of artificial intelligence technology on the architectural visualization process.

This study sheds light on the advantages and potential contributions of the integration of architectural visualization with AI compared to existing visualization methodologies such as rendering engines as of 2024. In this context, the problem of this research is whether AI-assisted visualization can achieve more realistic visuals. In this respect, the main objective of the research is to determine whether the use of AI technology can achieve more effective representative reference images compared to existing rendering engines. To test this, artificial intelligence and rendering engines were subjected to a comparative analysis. This will provide architectural designers with a perspective on the current and future rendering capabilities of artificial intelligence. The research is important in terms of providing a perspective on the preferability of AI in terms of realism in the architectural visualization market.

The increasing use of AI in the field of architecture makes it necessary to question the effects of this technology on creative processes and the ethical issues that arise. The integration of AI into architectural visualization processes causes the architect to delegate a certain amount of creative control to the technology. This carries the risk of the project slipping out of the hands of the architect and being driven by technology. This changing dynamic between creativity and control requires redefining the role of the architect. In particular, the increasingly autonomous decision-making capabilities of artificial intelligence contradict the anthropocentric nature of architecture, while raising the question of how vital human input is in the design process.

Another important dimension of the use of AI in architectural visualizations is its impact on cultural representation. To what extent do the visuals produced by AI accurately reflect cultural contexts, and can this representation be as authentic as designs made by human hands? No matter how successful AI is in processing cultural codes, it cannot completely replace the human touch in the creative process. This can lead to a loss of cultural authenticity in architectural visualization, and therefore the ethical use of AI in the design process is a critical point to be discussed. Beyond spatial aesthetics, architecture is a reflection of cultural and social norms, and the role of AI in this context needs to be carefully considered.

The impact of AI on the architectural profession is related to the artisanal nature of this discipline. Architecture has historically developed as a profession based on manual dexterity and human creative intelligence. However, the involvement of AI the creative process requires the architect to relinquish control to technology. This may result in the digitization of the artisanal nature of architecture. Although AI allows for faster project completion and more practical solutions, the exclusion of the architect from the creative process raises important questions about the roots of the profession. Architecture is not only an art of building, but also a product of culture and craft. The role of AI in this process has the potential to transform the traditional craft identity of architecture, a change that needs to be carefully considered from an ethical perspective.

2. Research in the field

According to Rane, the integration of artificial intelligence into architecture and its contribution to creativity, optimization of processes, and the cultural and social impacts it brings with it should be ethically evaluated (Rane N.L., Choudhary,

[3] AI: Artificial Intelligence.

and Rane J., 2023). According to Ko's research, the integration of artificial intelligence with ICM technology has enabled the production of parametric controllable models (Ko et al. 2023). In Enjellina et al.'s study, it is discussed that an AI text-to-visual image generator can go a step further to expand the design imagination by offering various design alternatives with high-quality images (Enjellina, Beyan, & Rossy, 2023). Hegazy & Saleh critically researched that AI has the potential to inspire and enhance architectural design, but should be used ethically and responsibly to avoid negative impacts on human creativity and design ethics (Hegazy & Saleh, 2023).

When we scanned the research conducted in the context of artificial intelligence and architectural visualization, we did not come across any research on the comparison of rendering engines and realism.

3. Method

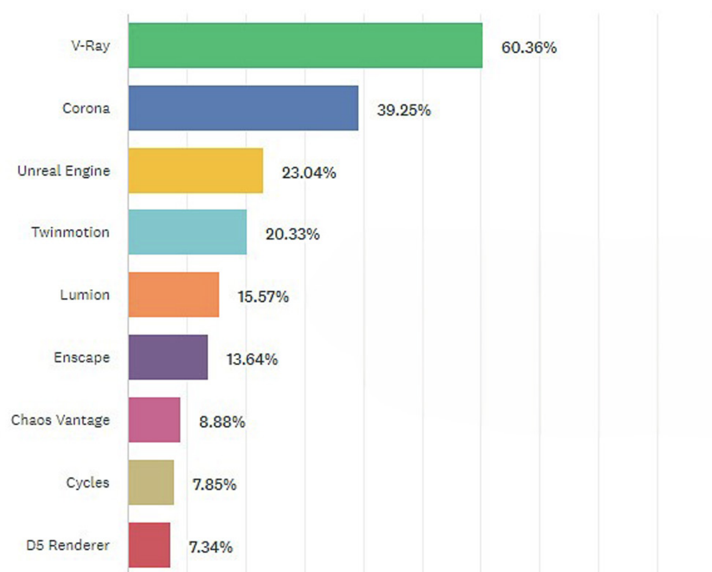
In this research, it is aimed to compare rendering engines and artificial intelligence appliºcations. For this purpose, the visuals created by using these tools as a sample were rated and compared with the survey method. In order to provide a scientifically sound basis, the tools compared were selected among the most widely used ones in their fields. In order to test the level of realism, based on scientific research on photorealism, six main criteria affecting realism were determined and the images produced by rendering engines and artificial intelligence applications were scored by architects within the framework of these criteria. The results obtained are presented graphically and opened to discussion.

3.1 Determining the render engine used

The scientific literature has been reviewed and no conclusions have been reached about the most preferred architectural rendering software. Therefore, we took the results of 2 recent studies presented in web resources as reference and added the software selected as the best of both studies to the research universe. The reason we chose these two sites is that they based their studies on the survey they conducted. Other comparison sites did not indicate that they were based on a specific method such as surveys etc. According to the results of the studies we selected, the 2 most preferred software are V-Ray and D5 Render.

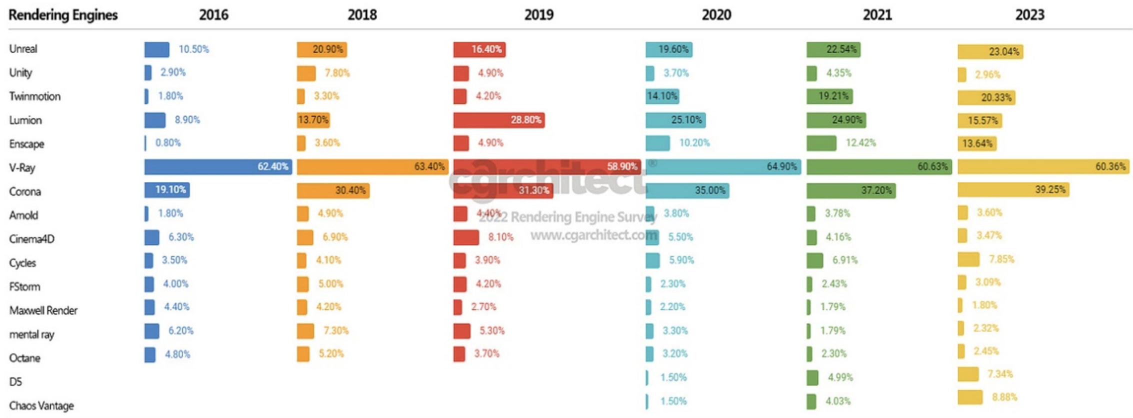
In a survey conducted in 2023 with the participation of 976 people, the graph of the answers to the question “Which 3D renderer(s) do you use for architectural visualization?” is given in Figure-1. According to Figure-1 and Figure-2, the most used architectural rendering software is V-Ray (Eloy, 2023) (see next p.).

Figure 1. The most used software for architectural visualization according to the survey



Source: Eloy, 2023

Figure 2. Ratio of market shares according to the surveys conducted



Source: Eloy, 2023

Figure 3. Scores obtained according to the rating

Cinema 4D Rate	Blender Rate	Lumion Rate	Twinmotion Rate	V-Ray Rate	Enscape 3D Rate	D5 Render Rate
2.9 / 10	7.9 / 10	7.1 / 10	6.0 / 10	7.0 / 10	8.0 / 10	8.8 / 10

Source: G2.com, n.d.

Another benchmarking study, taking into account user satisfaction ratings, found that D5 Render was the highest rated of 46 architectural rendering software (G2.com, n.d.). The voting results of the site are given in figure-3. The shortcoming of the data on this site is that participant qualifications are not clearly defined and the number of participants rating each software is not standardized.

In the galleries on the selected render engines' own sites, visualization experts present the images created using their own render engines, which they exhibit for their advertisements. For each rendering engine, 3 samples were selected from the rendered images in these galleries.

Then, the modeled images of the buildings in these architectural images, which have not yet been rendered, were used as reference images in the artificial intelligence application.

3.2 Determining the artificial intelligence platform used

The scientific literature was reviewed for the artificial intelligence application to be used and no clear information was found about the most common artificial intelligence application used for architectural rendering. However, there are many articles in web resources that aim to provide information and suggestions on this subject. Therefore, web resources were scanned. Web sources are not reliable enough as they do not have a scientific basis. In order to increase reliability, 17 sites that provide information and suggestions on the use of artificial intelligence in architectural visualization were identified. The number of sites mentioning the names of artificial intelligence software used in architecture was systematically tabulated. In total, 59 software are mentioned.

Since our aim is to select the most popular ones by determining the most recommended ones, when we remove the artificial intelligence sites that are mentioned 4 times or less from the table, the table becomes as shown in Table-1.

Purposive sampling technique was used to select the artificial intelligence application that will be a part of the research population. In this direction, we set some criteria for the artificial intelligence application to be suitable for the purpose of the research.

The concept of rendering in architecture includes the processes after modeling the design in three dimensions. Three-dimensional visualization is the process of automatically converting a three-dimensional solid model into two-dimensional images with photorealistic effects (daylight, material, texture, etc.) in a computer environment (Minoli, 2010). In other words, when we ask artificial intelligence to render, we expect it to preserve the form of the model we refer to. Today, there are text-to-visual and image-to-visual rendering artificial intelligence software. According to Ploennigs and Berger (2023), the text-to-image model (txt2img) is used when a completely new image is created from a text cue typed by the user. If an existing image is modified based on a text cue, Image-to-Image models (img2img) are used. These models change the style or layout of the image based on the text hint. When a certain part of the original image is deleted, the model can replace this part with completely new content based on the clues.

Artificial intelligence applications that only generate text-to-visuals are not within the scope of our subject. Among the artificial intelligence applications that generate images from images, it is necessary to choose an artificial intelligence

Table 1. Number of proposals of artificial intelligence software for architecture on the website

Artificial Name of the Intelligence Site	Number of Suggestions	Function	Coverage ✓ / Not Covered
Midjourney	15	Creativity/ Inspiration/ Design Idea	
DALL-E	8	Creativity/ Inspiration/ Design Idea	
Veras	8	Rendering/Design Idea	✓
ArkoAI	8	Rendering/Design Idea	✓
Adobe Firefly	8	Creativity/ Inspiration/ Design Idea	
ARCHITEChTURES	7	Feasibility/Model creation/ Floor plan creation	
Maket ai	7	Floor plan creation/Design Idea	
Stable Diffusion	6	Rendering/Design Idea	✓
Visoid	6	Rendering/Design Idea	✓
ArkDesign.ai	6	Feasibility / Schematic Design / Floor plan creation	
SidewalkLabs/Delve	6	Urban Design	
ArchitectGPT	5	Rendering/Design Idea	✓
Luma ai	5	Model creation/Scene creation	
Genera.so	5	Rendering/Design Idea	✓

Source: Not specified

application that is especially produced for architectural visualization, customized for rendering, and has the purpose of preserving the form.

Midjourney[4], Dall-E[5], Adobe Firefly[6] Although artificial intelligence software, such as artificial intelligence software, are widely used, they do not have specialized systems for architectural rendering. Although these platforms have the ability to render from image to image, they do not have the principle of preserving the given form. Therefore, they are not within the scope of this research.

Among the artificial intelligence software given in Table-1, the ones that fit the purpose of the research are Veras[7], ArkoAI[8], Stable Diffusion, Genera.so[9], Visoid[10] and ArchitectGPT[11]'is. Visoid was selected from these six software to be used in the article with a simple-random sample selection method[12].

3.3 Visual Production Process with Artificial Intelligence

This research proposes a process to achieve the most realistic result using artificial intelligence, schematised in Table-2:

Coloured 3D models of the selected images obtained from Sketchup are loaded into Visoid as reference images. The aim here is to apply rendering to the reference image. The resulting image was uploaded as a reference image to another artificial intelligence tool Krea, which is a developer with the ability to increase resolution and add detail (ToolsAi.net, n.d.). Environmental products such as people, trees, etc. were added to the obtained image in Photoshop Beta[13], again using artificial intelligence, for more realistic results. Thus, the final image, which is completely produced in artificial intelligence, is ready to be compared with the versions created with rendering engines.

While rendering with Visoid, the steps in Figure-4 were followed (see next pp.).

The settings were chosen to best suit our purpose and all images were produced with the same standards. The "input image blend" and "geometric freedom" properties were fixed at 0.95 and 1.0 respectively. Our aim is to achieve a realistic effect as well as preserving the form. When the "geometric freedom" setting is set to 0 and we try to be completely faithful to the form, the result is close to the given color 3D model not only in form but also in appearance. Therefore, it looks more like a sketch image than a realistic image. For this reason, it is kept at 1.0 instead of 0. For "input image blend" The value of 0.95 was set for the same reason. In all images, words from Visoid's own prompt library were used.

The limitations of this research include the changes in these settings and the fact that the artificial intelligence produces slightly different visuals each time (see next p.).

When using Krea.ai and Photoshop Beta, the steps in Figure-5 were followed (see next pp.).

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4 The bot software works with descriptive word codes following the "/imagine" command. Reference images added to Midjourney are used as inspiration for new images to be produced. The Midjourney interface is aimed at creating random combinations that are less dominated by the user than other programs ("Quick Start", n.d.).[2] Nacionalidad: turco; adscripción: Mimar Sinan Fine Arts University, Institute of Science and Technology, Department of Architecture, Building Information, Turquía; doctorado Mimar Sinan Fine Arts University, Turquía; email: gokhan.kocyigit@mmsgsu.edu.tr, ORCID: https://orcid.org/0000-0002-9748-7913

5 (Goh, Betker, Jing, & Ramesh, n.d.)

6 Adobe Firefly, which features rendering from text, generative fill and generative expand, does not promise architectural rendering (Adobe.com, n.d.).

7 It offers the ability to process and fine-tune the given 3D model. It allows for fine-tuning of geometry preservation (EVOLVELAB, n.d.).

8 It gives architects a powerful medium to visualize their designs by bringing 2D sketches and models to life, transforming them into realistic images that give architects a glimpse of their real-world creations (ArchitizerTech, n.d.).

9 It can create images of buildings from text descriptions and can also render architectural drawings photorealistically (Zubenko, n.d.).

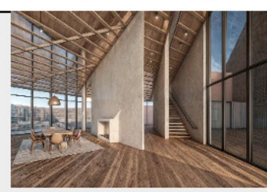
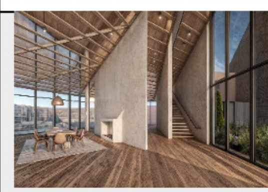
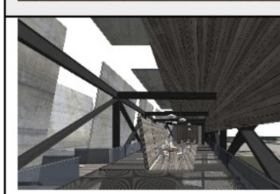
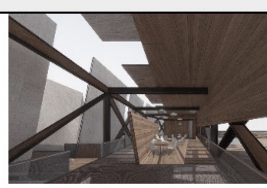
10 You can use Visoid as a rendering engine to create high-quality visualizations based on a file from your favorite 3d application such as Twinmotion, Enscape or 3d studio max (VISOID, n.d.).

11 ArchitectGPT has Sketch To Image feature that converts your sketch drawings, AutoCAD, Revit and SketchUp 3D visualizations into photorealistic images. It offers concept-to-visualization for architects, interior designers and real estate developers (ArchitectGPT, n.d.).

12 The success in preserving the form and its ease of use in the trials with these sites were influential in our choice of Visoid.

13 Photoshop Beta was produced with the integration of Adobe Firefly with Photoshop. It is used for adding and removing objects and generative fill for creating atmospheres and landscapes (Adobe, 2024).

Table 2. Production process of artificial intelligence visual

Production process table of the AI image to be compared			
Sketchup 3D Model	Visoid	Krea.ai	Photoshop Beta
			
			
			
			
			
			

Source: Not specified

Figure 4. The table on the left contains the general settings we use; the table on the right contains Visoid's promt library

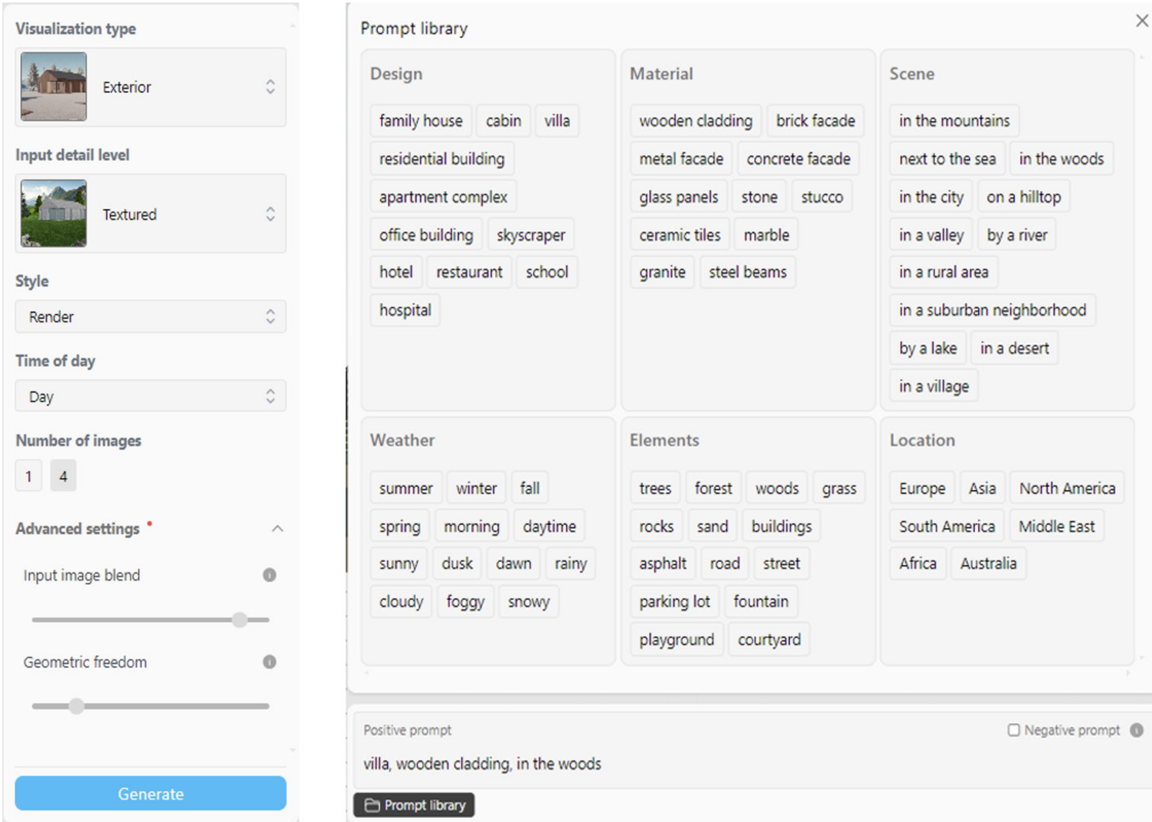


Figure 5. The table on the left shows the general settings we use in Krea.ai; the image on the right shows an example of entering prompts in Photoshop Beta

Sources: Not specified

Krea.ai did not enter any prompt, it was only expected to improve the visual. When the "AI Strength" setting is entered too much, the form in the image is distorted, when it is entered too little, it does not make enough changes. When the "Resemblance" setting is entered too much, there is not enough change, when entered too little, the form is not preserved enough. The "Clarity" setting gives unrealistic results when too much value is entered. As a result of the experiments, these adjustments were given values of 0.40, 0.80 and 0.60 respectively.

The use of artificial intelligence in Photoshop Beta involves entering the desired prompt into the writing panel, which is activated for AI usage after selecting the section to be modified, or where an object is to be added or removed, using traditional selection tools. The prompts entered were determined by attempting to replicate the visual output produced by rendering programs. In other words, to ensure more controlled comparisons, we aimed to standardize factors such as weather, vegetation, and environmental elements in the images. For instance, if the rendered image depicted foggy weather, the relevant areas of the sky were selected, and the prompt "foggy" was entered while generating the AI image. Similarly, if the rendered image featured a broad-leaved tree, the same location was selected during the AI generation, and a prompt describing the tree was entered.

These adjustments were carried out in this manner. As full control over AI has not yet been achieved, the actions we took are considered among the limitations of this research.

All 3D model images were passed through the process shown in Table-2 to obtain the artificial intelligence product images to be compared.

3.4 Determination of Photorealism Criteria for Comparison

The criteria to be scored to measure realism were determined on the basis of the information obtained from the literature review:

Rendering is the process of converting a geometry model into a visual format. This process consists of various stages such as modeling, material and texture editing, virtual light placement and finally rendering.

According to Terzioğlu (2023), the word "rendering" is one of the most commonly used terms in the field of three-dimensional visualization. Rendering is the imaging process created by enhancing the models used in many sectors and applied with Computer Aided Design programs with various visuals such as material, texture, light, color.

According to Symeonidou and Papapanagiotou (2021), rendering usually involves the assignment of materials, textures, lighting conditions and cameras, while image editing deals with issues such as transparency, blending, filters, as well as the addition of elements or objects.

According to Özer Baş and Onaran (2022), architectural models made on the computer should be transformed into a more realistic image with photorealistic imaging programs, sometimes these models should be turned into videos (animation) with multiple images with camera and natural effects (wind, gravity, rain, sun, etc.), and more realistic presentations can be created by adding some visual elements such as plants, trees, people.

According to Maulana and Kurniawan (2019), rendering plays a critical role in animation and visual content creation. Photorealistic rendering techniques can be used to achieve realistic images, and different rendering methods can be applied for stylistic models.

According to Olgun and Yılmaz (2014), the materials we will use to get a realistic rendering in our scene are of great importance. What should be considered when creating the materials is to imitate them in the closest way to reality. For this, the properties of the materials such as light transmittance, transparency, reflection and value should be analyzed well.

According to Amasyalı (2019), the contribution of the use of light to the photorealism effect in visualization is undeniable. The effect of light on colors, the shadow it creates and its contrast with other areas strengthen the perception of realism in the visual. According to Symeonidou and Papapanagiotou (2021), sun and artificial light contribute significantly to the appearance of reflective surfaces and give realism to the image.

According to Dinur (2022), almost every aspect of photorealism is based on color. Color defines not only illumination, but also surface properties, reflections, distance, depth, atmosphere, environment, and even camera and lens characteristics. Sometimes a simple color adjustment is all that is needed to make things "look real".

With reference to the information reviewed, 6 criteria affecting realism for comparison were identified and illustrated in table-3 with a sample survey model.

a. Lighting / b. Material / c. Landscaping / d. Realistic effects and atmospheric conditions / e. Color accuracy and harmony / f. Camera

3.5 Designated Render Images

D5 Render products and AI versions are presented in Table-4; V-Ray products and AI versions are presented in Table-5 (see next p.).

Table 3. Sample survey model

Image-1: In this section, the image to be evaluated will be given.										
Criteria	Scoring 1-10									
	1	2	3	4	5	6	7	8	9	10
1. Lighting										
2. Material										
3. Landscaping										
4. Realistic effects and atmospheric conditions										
5. Color accuracy and harmony										
6. Camera										

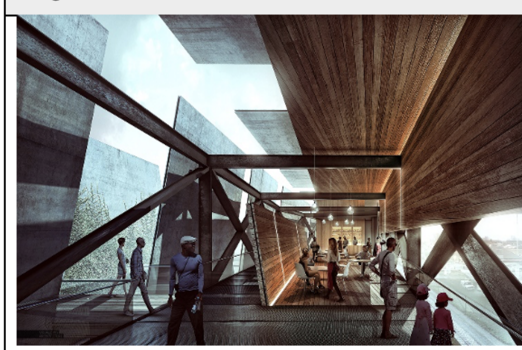
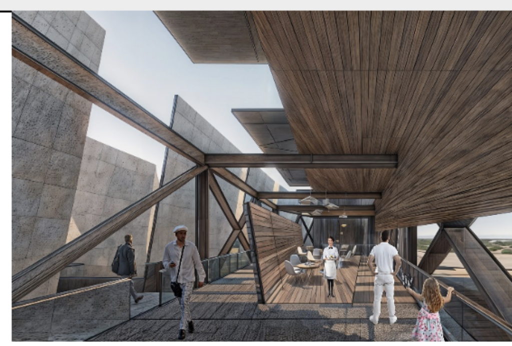
Source: Not specified

Table 4. Images selected for D5 render and their AI generated versions

Images for D5 Render:	
D5 Render	Artificial Intelligence
 Image-1	 Image-2
 Image-3	 Image-4
 Image-5	 Image-6

Source: Not specified

Table 5. Images selected for V-Ray and their AI generated versions

Images for V-Ray:	
V-Ray	Artificial Intelligence
 Image-7	 Image-8
 Image-9	 Image-10
 Image-11	 Image-12

Source: Not specified

4. Analysis and findings

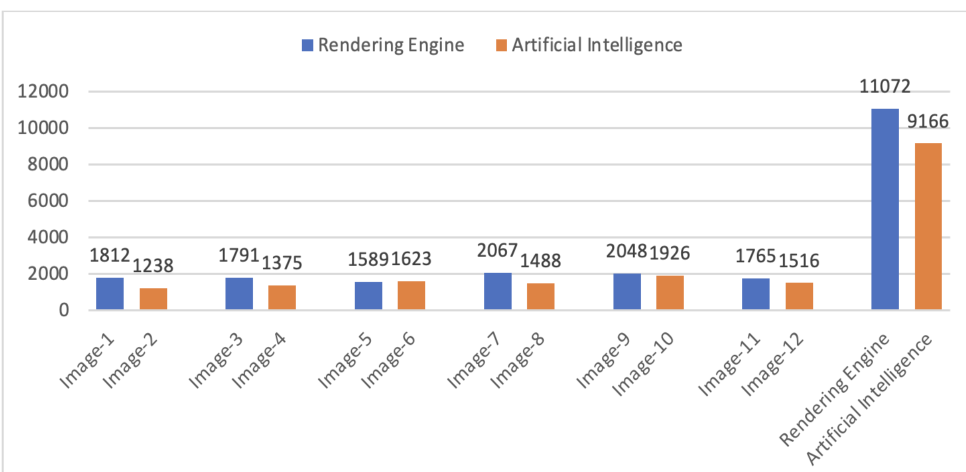
The identified visuals were subjected to a survey with the participation of 51 architects. The scoring results are given in the table in Table-6.

According to the scoring results, the total score of the AI visuals was compared with the total score of the rendering engine visuals. The images created with the same model were also compared with each other. Figure-6 shows these comparisons graphically.

Table 6. Scores of the visuals obtained as a result of the survey

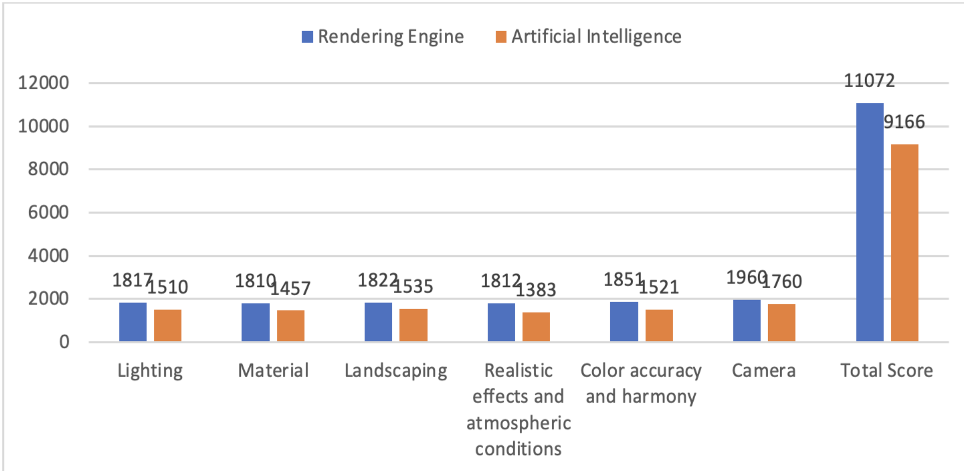
Images/ Criterias	Lighting	Material	Landscaping	Realistic effects and atmospheric conditions	Color accuracy and harmony	Camera	Total Score
Image-1	305	282	297	290	308	330	1812
Image-2	187	184	219	177	205	266	1238
Image-3	309	301	274	282	309	316	1791
Image-4	219	225	218	207	241	265	1375
Image-5	220	251	276	270	271	301	1589
Image-6	273	267	259	246	278	300	1623
Image-7	345	331	359	349	342	341	2067
Image-8	241	214	275	231	231	296	1488
Image-9	350	348	333	337	331	349	2048
Image-10	332	322	311	303	313	345	1926
Image-11	288	297	283	284	290	323	1765
Image-12	258	245	253	219	253	288	1516

Figure 6. Pairwise comparisons and total comparison



Sources: Not specified

Figure 7. Total comparisons for criterias



Source: Not specified

5. Results and discussion

In this paper, a comparison is made between artificial intelligence and rendering engines integrated into architectural visualisation on the realism of the final product. The 2 most commonly used rendering engines are V-Ray and D5 Render according to the results of two surveys we found in the scans made from web resources. The artificial intelligence used for rendering was determined as Visoid according to the scan we made in web resources. On the websites of the render engines, 3 images created using their own software were determined. Coloured Sketchup models of these images were used as reference and rendered in artificial intelligence. A three-stage process is proposed for the visual production process from artificial intelligence. After rendering with Visoid, Krea.ai, an artificial intelligence enhancer, was used. As the last stage, Photoshop Beta was used for environmental element placement and the final product was obtained. The 6 visuals obtained in this way were scored between 1-10 points by 51 architects on 6 main criteria (Lighting, Material, Landscaping, Realistic effects/atmospheric conditions, Colour accuracy and harmony, Camera) that determine the realism we determined from the literature review with the versions obtained in the rendering engine.

In the research, the images we took from the render engines' websites for comparison were produced by different visualization experts. However, since the comparisons will be made in pairs, the important thing is the Sketchup model used in the AI and the render engine is the same in the same pairwise comparison. Whichever Sketchup model was used to produce the image in the rendering engine, the same Sketchup model produced by the same person was used to produce the same image in the AI. Since we use our own computer for the production in artificial intelligence, there is a difference in the device used between the image produced by us and the rendered image produced by the visualization expert. This situation is among the limitations of the research. The resolution differences that may occur due to this situation were eliminated; the images were presented to the survey in the same resolution.

The 3-stage production process with artificial intelligence we propose is based on personal preferences in many places. The reasons for the choices made are explained, but more concrete grounds are needed. This is another limitation of this research. There are very few studies on the process of creating architectural renderings with artificial intelligence. Since it is a new field, research on this subject is needed. Although the process we propose can be used as of 2024, it is predicted that it will be outdated in a short time considering the rapid development of artificial intelligence. 3 Artificial intelligence software that can provide the process we have provided with a single stage can be developed in the future. In this context, new research is needed in the future.

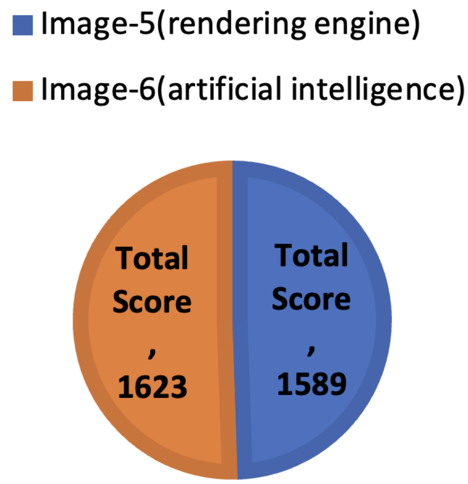
Again, the realism measurement model that we propose in this research was produced due to the lack of sufficient research on this subject. In order to achieve photorealistic results in architectural renderings, 6 main criteria that stand out at the point of imitating reality were determined with reference to scientific literature. This model provides a general framework. Realism is related to the way reality is perceived (Amasyalı, 2019). Therefore, it is a qualitative concept. Being qualitative makes it difficult to measure the realism value. In order to make this measurement in our proposed model, we used the operationalisation method to quantify the qualitative realism value. We aimed to reach quantitative results with these scores by asking people (architects) trained in this field to score these criteria. In this context, much more detailed models can be produced in future studies. Our proposed model can serve as a template for these studies.

The participants of the questionnaire for the analysis of the research were determined as architects since they were trained in architectural visualisation. With the participation of a total of 51 architects, rendering engines and artificial intelligence were subjected to a general scoring according to the given criteria.

The results of the survey are shown in the table-6 and the graphs in figure-6 and figure-7. The images obtained from the rendering engines received 1906 points more than the images obtained with artificial intelligence as a total score. In pairwise comparisons, in only one of the 6 comparisons, the AI image scored more points than the rendering engine image. Of these, image-6 scored only 34 points more than image-5. It is shown in Figure-8. In all other comparisons, the rendering engine images scored more points than the AI versions.

The hypothesis of this research was that by 2024, AI in architectural visualisation would be able to create more realistic architectural renderings compared to traditional rendering engines. However, the results of the analysis show that, contrary to our hypothesis, AI is not successful enough to create architectural renderings as realistic as rendering engines by 2024. It is clear that AI is advancing rapidly in the field of architectural visualisation and promises potential. However, the findings of this study show that AI still has certain limitations and struggles to reach the level of realism offered by traditional rendering engines.

Figure 8. Total comparisons between Image-5 and Image-6



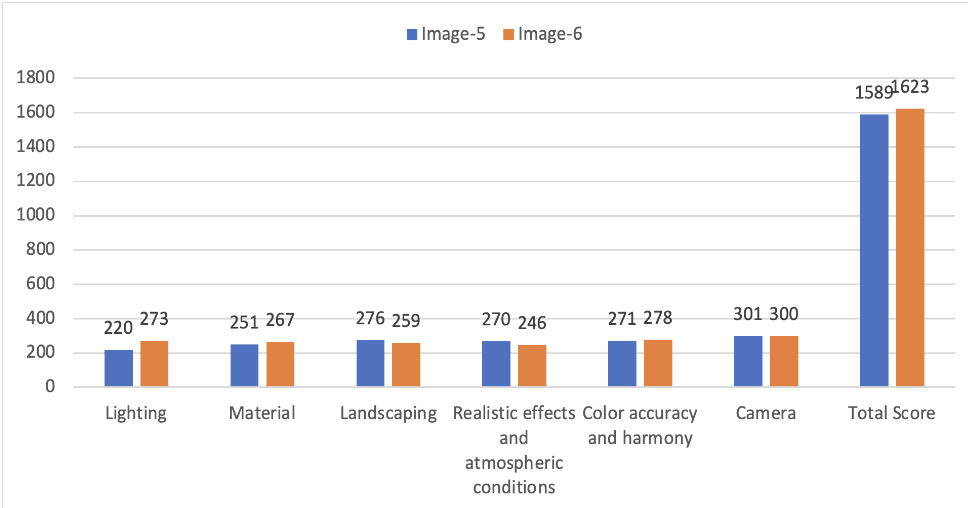
Sources: Not specified

If we analyse the scores by criteria, we can see that the rendering engine visuals score higher in the scenery, realistic effects/atmospheric conditions and camera criteria and are more competent than the AI versions in all comparisons. In the criteria of lighting, materials and colour accuracy/compatibility, only image-6 (produced with AI) scored higher than image-5 (produced with rendering engine). It is shown in Figure-9 (see next p.).

The criterion where the AI came closest to the rendering engines in total points was the camera criterion. In this criterion, it scored 200 points less than the rendering engine. Assuming that features such as focal length, exposure, background adjustments, and perspective constitute the camera criterion, the score collected by artificial intelligence in this context is slightly behind the score obtained by rendering engines.

The criterion in which AI is the furthest away from the rendering engines in total points is the criterion of realistic effects and atmospheric conditions. AI scored 429 points less than rendering engines in this criterion. Nowadays, rendering engines are able to reflect various atmospheric conditions very close to reality. According to our results, the AI scored more should be developed. One of the points where artificial intelligence is lacking in the process is that it does not give the user one hundred percent control in other preferences, especially in preserving the form in the given 3D model.

Figure 9. Comparison of criteria for Image-5 and Image-6



Sources: Not specified

It cannot render detailed forms or textures at the desired level. The same situation is seen in lighting and material criteria. For example, it is difficult to define and depict a finely detailed wire mesh metal material. There is also a need for improvement in the positioning and behavior of light in artificial lighting. According to our analysis results, in 5 out of 6 comparisons, rendering engines scored higher than AI in the lighting criterion. Only in one comparison did the AI image outperform the AI in the lighting criterion. This suggests that AI has potential in lighting.

As for the landscaping, although the creation process is under the control of artificial intelligence, manual control has also come into play from time to time in the production process we used in this research. In this regard, we generally used Photoshop Beta, we provided product placement with prompts. The selection of product positions in the process was under our own control. Although this control power provides an advantage from time to time, the articulation can cause unnatural sizes and colors. After a few trials, the desired result can be achieved. Artificial intelligence needs to be developed on these issues.

According to the results of our research, although it is not yet more effective than rendering engines in creating photorealistic architectural visuals in 2024, according to our comparative analysis, it is capable of competing and there is not a big difference in the scores. It is predicted that this difference will decrease even more in the near future. In this context, artificial intelligence has the potential to make a positive contribution to the architectural visualization process in terms of time, creativity and quality as it approaches rendering engines. More research is needed in this context.

In general, today's rendering engines are more efficient than artificial intelligence software in terms of photorealism. One of the advantages of artificial intelligence in architectural visualization, which can probably increase efficiency the most, is that it can produce in very short times. According to Özer Baş and Onaran (2022), the rendering process can take a long time as it puts a lot of load on the computer's processor and therefore a high-performance computer may be required. The speed and number of processors used affect the rendering time. Unlike rendering engines that take hours, artificial intelligence can render in a much shorter time. In terms of creating photorealistic renderings, it promises great potential for architects in terms of both quality and duration in the future, if it comes to the same level with rendering engines and perhaps gets ahead. New research and studies are needed on this subject.

Our research presents a cross-sectional perspective on the integration of artificial intelligence in architectural visualization. It is aimed to create a discussion on the contribution of artificial intelligence to the visualization process, which closely affects the architectural design process. The two separate models we propose about the process of measuring realism and creating architectural renderings with artificial intelligence can make significant contributions to current and future architects and researchers both in practice and theory. In this direction, the findings of our research reveal how artificial intelligence technologies can be used more effectively in architectural visualization and the future development potential of these technologies. C

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Bibliographic references

AcanthusAlchemist. (2023, December). The best AI image generators for architecture. Pixels to Plans. https://pixelstoplans.com/the-best-ai-image-generators-for-architecture/

Adobe. (2024, May 22). Masaüstünde Photoshop (Beta). https://helpx.adobe.com/tr/photoshop/using/photoshop-beta-desktop-app.html (Accessed: 9 June 2024)

Adobe.com. (n.d.). Adobe Firefly. https://www.adobe.com/tr/products/firefly.html (Accessed: 9 June 2024)

ALL RENDER. (2024). İş akışınızı hızlandırın: Yapay zeka ile render alma. https://www.allrender.net/post/gelecegin-tasarim-sureci-yapa-zeka-ve-mimarlik

Amasyalı, H. (2019). İç Mimari Görselleştirmelerin Fotogerçekçi Etki Bakımından İncelenmesi (Master's thesis). Mimar Sinan Fine Arts University, Institute of Science, Istanbul.

ArchitectGPT. (n.d.). Sketch To Image: Where Your Designs Leap Off the Page. https://www.architectgpt.io/ (Accessed: 9 Haziran 2024)

ArchitizerTech. (n.d.). ArkoAI.
https://tech.architizer.com/listing/arkoai.html#:~:text=ArkoAI%20is%20an%20AI%2Dpowered,visual%20masterpieces%20that%20mirror%20reality (Accessed: 9 June 2024)

Arkitera. (2023). D5 Render | Yeni Standart Gerçek Zamanlı 3D Rendering. https://www.arkitera.com/tanitim/d5-render-yeni-standart-gercek-zamanli-3d-rendering/

Balderson, K. (2024, April 23). Best AI image generators for architecture. MSPowerUser. https://mspoweruser.com/ai-image-generator-architecture/

Boz, B. (2023, November 18). Top 33 AI tools for architects and designers. Vagon Blog. https://vagon.io/blog/best-ai-tools-for-architects-and-designers/

chaosgroup.com. (2024). What is V-Ray ?. https://www.chaosgroup.com/vray

CO-architecture. (2024). Top 14 AI tools for architects and designers. https://site.co-architecture.com/artificial-intelligence-ai/top-14-ai-tools-for-architects-and-designers/

Curved Axis. (2024, February 5). 9 Practical AI uses in architectural visualisation. https://www.curvedaxis.com/news/9-practical-ai-uses-in-architectural-visualisation

Dinur E. (2022). The Complete Guide to Photorealism for Visual Effects, Visualization and Games. Routledge, sf: 31.

Eloy, R. (2023, August 02). 2022 Architectural Visualization Rendering Engine Survey Results. CGarchitect. https://www.cgarchitect.com/features/articles/450b3b68-2022-architectural-visualization-rendering-engine-survey-results . Accessed: 05 May 2024.

Enjellina, Beyan, E. V. P. & Rossy, A.G.C. (2023). A Review of AI Image Generator: Influences, Challenges, and Future Prospects for Architectural Field. Journal of Artificial Intelligence in Architecture. 2(1), 53–65. https://doi.org/10.24002/jarina.v2i1.6662

EVOLVELAB. (n.d.). VERAS. https://www.evolvelab.io/veras (Accessed: 9 June 2024)
Frew, S. (2023). 15 top AI tools for architects and designers. Architizer. https://architizer.com/blog/practice/tools/top-ai-tools-for-architects-and-designers/
G2.com. (n.d.). Best architectural rendering software. https://www.g2.com/categories/architectural-rendering (Accessed: 20 April 2024)
Goh, G., Betker, J., Jing, L., & Ramesh, A. (n.d.). DALL-E 3. OpenAI. https://openai.com/index/dall-e-3/ (Accessed: 9 June 2024)
Hegazy M., Saleh A. M. (2023). Evolution of AI Role in Architectural Design: Between Parametric Exploration And Machine Hallucination. MSA Engineering Journal. Volume 2, Issue 2.
Ko J., Ajibefun J., Yan W. (2023). Experiments on Generative AI-Powered Parametric Modeling and BIM for Architectural Design. arXiv:2308.00227
Li, P., Li, B., & Li, Z. (2024). Sketch-to-Architecture: Generative AI-aided Architectural Design. Eurographics. The European Association for Computer Graphics.
Makarouni, E. (2023). Tech for architects: 7 top AI tools for architectural rendering and visualization. Architizer. https://architizer.com/blog/practice/tools/top-ai-tools-for-architectural-rendering-visualization/
Maksymiuk, I. (2024, March 5). The top 5 AI tools for architectural rendering and visualization. inna3d. https://www.inna3d.com/post/the-top-5-ai-tools-for-architectural-rendering-and-visualization
Maulana, Much. & Kurniawan, Ichwan. (2019). Pengaruh Banyaknya Chunks Dan Prıorıty Render Anımatıon 3d Terhadap Waktu Render Menggunakan Anova One Way Dengan Menerapkan Parallel Computıng Render Engıne. IC-Tech, 14(1), 47–60.
Minoli, D. (2010). 3D television (3DTV) technology, systems, and deployment rolling out the infrastructure for next-generation entertainment.
Montenegro, A. L. (2024, February 22). Top 8 AI tools for architects. Microsol Resources. https://microsolresources.com/tech-resources/article/top-8-ai-tools-for-architects/
Muslihat, D. (2024, April 8). Top 12 AI tools for architects in 2024. Chaos Enscape. https://blog.enscape3d.com/ai-tools-for-architects
Olgun, R. ve Yılmaz, T. (2014). Yapay Zeka Mimarlığında Bilgisayar Destekli Tasarım ve Tasarım Aşamaları. Niğde University Journal of Engineering Sciences, Volume 3, Issue 1, 48-59.
Özdemir, Y. (2023). AI tools for architecture and design. Reddit.
https://www.reddit.com/r/archviz/comments/18csi84/ai_tools_for_architecture_and_design/?rdt=57891
Özer Baş, G., & Sayıl Onaran, B. (2022). İç Mimarlık Meslek Süreci. Ankara, Turkey: İKSAD Publishing House.
Panicker, S. (2022). AI-Inflected Art/Architecture: Who(or rather, what) is the artist/architect?. Blueprınt. 2022, 3(2), 15–36.
PlanMan. (2023, November 13). AI tools for architects. https://www.planman.app/blog/architects/ai-tools/
Ploennigs, J., & Berger, M. (2023). AI art in architecture. AI in Civil Engineering, 2(8). https://doi.org/10.1007/s43503-023-00018-y
Popovski, F., Spasov, N., Mijakovska, S., & Nalevska, G. (2020). Comparison of Rendering Processes on 3D Model. International Journal of Computer Science and Information Technology, 12, 19–28. https://doi.org/10.5121/ijcsit.2020.12502
Quick Start. (n.d.). Midjourney Documentation. https://docs.midjourney.com/docs/quick-start (Accessed: 9 June 2024)
Rane N.L., Choudhary S.P. and Rane J. (2023). Integrating ChatGPT, Bard, and Leading-Edge Generative Artificial Intelligence in Architectural Design and Engineering: Applications, Framework, and Challenges. International Journal of Architecture and Planning. 3(2) (2023) 92-124.
RealSpace. (2023, November 21). Revolutionizing design: Top 10 AI-powered architectural rendering programs for innovative creations. https://www.realspace3d.com/blog/revolutionizing-design-top-10-ai-powered-architectural-rendering-programs-for-innovative-creations/
RealSpace. (2024, January 5). 7 best AI tools for architects in 2023: Revolutionizing architectural design. RealSpace. https://www.realspace3d.com/blog/7-best-ai-tools-for-architects-in-2023-revolutionizing-architectural-design/
Schwarz, Y. (2024, March 25). AI rendering: Transforming architectural visualization. Pelicad. https://www.pelicad.com/blog/ai-rendering

Setyaningfebry, F. U., Felasari, S., & Michelle, B. (2023). Desarrollar Un Sıtıo Web De Renderızado Basado En La Experıencıa De Los Renderızadores. Grafica, 23-36.

Sharma, P. (2023, October 15). 8 AI-powered architectural rendering programs you should try. parametric-architecture. https://parametric-architecture.com/8-ai-powered- architectural-rendering-programs-you-should-try/

Symeonidou I., Papapanagiotou P. (2021). From (Flat) Drawings to the (Ultra) Real: A Taxonomy of Architectural Visualizations. SIGraDi 2021, Designing Possibilities, Ubiquitous Conference.

Terzioğlu, S. V. (2023). Bilgisayar Estekli Görselleştirmede Fotogerçekçiliğin Yapılı Mekânlar Üzerinden İncelenmesi (Master's thesis). Antalya Bilim University, Graduate School of Education, Antalya.

ToolsAi.net. (n.d.). Krea AI: Real time AI Image generator, Upscale, Enhancer. https://toolsai.net/tool/krea-ai/ (Accessed: 9 June 2024)

VISOID. (n.d.). https://www.visoid.com/ (Accessed: 9 June 2024)

Zubenko, R. (n.d.). Arch-E: Architectural AI. Genera. https://www.genera.so/apps/arch-e (Accessed: 9 June 2024)