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Experiencing Ancient Ephesus: A Journey Through Time with 3D, XR and AI

By Ahmet Denker[*], *Alp Kayra Dağıstanlı*[±], *Arda Güler*[°], *Arif Emre Sevil*[•], *Ceren Özcan*[♦], *Ecem Suzan Ulaş*[♠], *Mert Kaytaz*[♥], *Serkan Kahraman*[♣] *& Yiğit Bozkurt*[·]

The primary objective of this project derives from the desire to travel back in time to the ancient city of Ephesus, which has largely lost its former luster, and to experience it as it was in its brightest days in the 2nd -3rd centuries. A new virtual and immersive experience has been created using the capabilities of 3D reconstruction (3D), extended reality (XR) and artificial intelligence (AI). This project has been a merger of history with modernity. This time travel to the past was made possible by combining historical information with cutting-edge technologies. An extensive study, including an analysis and comparison of existing technologies as well as a comprehensive review of historical and archaeological information, was critical to the fateful and compelling recreation and experience of ancient Ephesus. The Roman landmark buildings were digitally reconstructed and restored to their original state using various sources. The 3D virtual Ephesus experience, augmented with Animation, Gaming, and AI, creates an immersive experience for visitors, enhancing interaction with the historical district and ancient Ephesians' avatars. The project created an immersive journey to Ephesus, featuring notable structures like the Temple of Artemis Harbor Gate, Grand Theater, Celsus Library, and Agora, providing unprecedented levels of presence and immersion.

Keywords: *Ephesus, 3D reconstruction (3D), Extended Reality (XR), Artificial Intelligence (AI), journey through time*

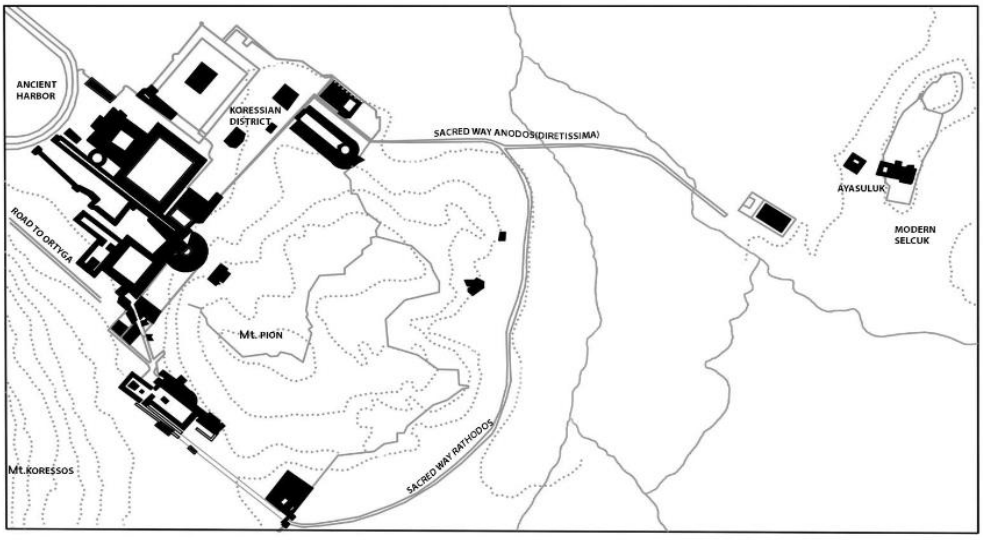
Introduction

Located twelve hundred miles east of Rome and now approximately two miles inland from the Aegean shoreline of Turkey, are located the remains of Ephesus to the south of the Cayster River, in close proximity to the contemporary settlement of Selcuk (Map 1). Ephesus had an incredible role in ancient history. The ancient city was Asia's economic, political, and religious hub, serving as the proconsul's seat, metropolis, and significant pilgrimage destination due to its ecclesiastical heritage. Ephesus is an ancient Ionian Greek city; it was also the home of a world

[*]Professor, Istanbul Bilgi University, Turkey.
[±]Research Student, Istanbul Bilgi University, Turkey.
[°]Research Student, Istanbul Bilgi University, Turkey.
[•]Research Student, Istanbul Bilgi University, Turkey.
[♦]Research Student, Istanbul Bilgi University, Turkey.
[♠]Assistant Researcher, Istanbul Bilgi University, Turkey.
[♥]Research Student, Istanbul Bilgi University, Turkey.
[♣]Research Student, Istanbul Bilgi University, Turkey.
[·]Research Student, Istanbul Bilgi University, Turkey.

wonder: The Temple of Artemis. Originally established by the Carians, it became one of the 12 Ionian Cities and played a role in both the Persian and Peloponnesian wars. Alexander the Great captured it in 333 BC and it thrived during the Hellenistic era. In 133 BC, Rome gained control of the city and it subsequently became the capital of the Roman province of Asia under the reign of Emperor Augustus. Once, it was Imperial Rome's greatest and arguably the most vital harbor city in the East. Now completely silted and hidden amidst marshy woodlands, this harbor used to function as the central hub for maritime trade, playing a pivotal role in the prosperity of the Roman Empire.

Map 1. *Ancient City of Ephesus Is Located Twelve Hundred Miles East of Rome and Now Approximately Two Miles Inland from the Aegean Shoreline of Turkey*



Ephesus also held significant importance in the early development of Christianity. It was personally visited by St. Paul, who wrote a letter specifically addressed to the church in Ephesus, known as the Letter of Paul to the Ephesians. In AD 262, the

Goths devastated the city and the temple, both of which never regained their former state. The contemporary location has thoroughly excavated ruins.

With the city now in ruins, some questions emerged, such as "What was it like to experience it as it was in its brightest days in the 2nd–3rd centuries?" This particular question tingled our minds. Until recently this question was considered impossible to answer. Many researchers tried to solve this problem with various visualization attempts such as by drawings, artistic impressions or building hand-made models, but none were enough to visualize the original. Thanks to developments of digital visualization technologies, capturing the grandiose, beauty and luster of the ancient city of Ephesus while remaining faithful to the original has become possible.

This article aims to reconstruct Ephesus as in its most glorious days and enable a virtual visit to those days. This reconstruction harnesses cutting-edge digital technology tools and resources from 2D drawings to 3D models. The landmark structures were revived using 3D modeling technology 3D Immersive Virtual Worlds offer a detailed, immersive educational experience (Corcini et al. 2016). The terrain was reconstructed using height maps and the unreal engine. In order to provide users with a more immersive experience, artificial intelligence was utilized to maximize their experience.

A comprehensive literature research was conducted to generate a precise three-dimensional model of the ancient city of Ephesus, with the goal of faithfully recreating its original look and providing an exact solution to the previous question. It's possible to have the chance to interact with it in the virtual world.

The topic centers on utilizing cutting-edge technology and software resources to accurately portray the historical reality of a temple. Virtual reality compounded with XR, and AI is highly attractive because it enables the viewer to become fully engaged in the virtual world, going beyond being a passive observer (Denker 2023). The final images are shown in the result section.

Literature Review

The most valuable resource for this work is provided by Ephesus itself, which is one of the best-preserved ancient cities in the world. In addition, the large number of ancient literary works, articles, excavation reports, drawings and sketches that more than 150 years of excavations left us, is an extraordinary heritage still not fully explored. As stated above, Ephesus has been the site of archaeological research for over 150 years - excavations were initiated by the British Museum and have been carried out by the Austrian Academy of Sciences (OeAI) since 1895. The rich archaeological and historical resource base produced by these activities has made it possible to trace the development of Ephesus and its rise as an urban mega-center. The collection of sample data from different time periods referring to past eras makes it possible to add a time dimension to the modeling. There are many sources in which the data obtained as a result of Ephesus research are presented. Undoubtedly the most important of these is the "Forschungen in Ephesos" series, the first volume of which was published as early as 1906 (Österreichisches

Archäologisches Institut [Contr.]: Forschungen in Ephesos (Forschungen in Ephesos, 1906) n.d.). The Austrian Academy of Sciences (OeAW) has been publishing the series under its own imprint since 1977. Another example is Ephesos: 100 Jahre österreichische Forschungen (Hill 1999), published by the Austrian Archaeological Institute, which presents a panorama of Austrian archaeological research in Ephesus. On the other hand, Ephesus was one of the three best preserved ancient cities in the world (along with Pompeii and Palmyra), but the complete destruction of Palmyra in the Syrian civil war has reduced the number of such cities to two. So, in terms of the knowledge needed to inform the aims and objectives of our project, and the impact the project outputs will have, there is no better place in the world to work. One of the sources of literature that we utilized in this project is the reference book "Palmyra, Bride of the Desert - Images, Ruins and Cultural Memories", co-authored by the first author (Denker et al. 2018). This book describes in detail how a completely destroyed ancient city was reconstructed in a virtual environment using modern technologies.

A thorough investigation was conducted by extensively reviewing hard copy and utilizing online sources before envisioning the virtual realm. Founded pieces of literature helped to place the structures according to the map as it was in the 2nd -3rd century (Quatember 2010). Another book was reviewed in order to understand the area of Ephesus and the structures in the city (Highlights of Ephesus n.d.). This survey facilitated a comprehensive comprehension of Ephesus' historical significance, and by thoroughly examining scholarly material, it became far more lucid to recreate the city.

To accurately reflect the ancient city of Ephesus to the users, a road map was drawn from the mentioned works of literature. In the light of other research, bringing the ancient city of Ephesus into the virtual world was executed impeccably. Thanks to the amalgamation of developing modeling technologies and related research conducted in the past, Ephesus came to life in all its glory.

Methodology

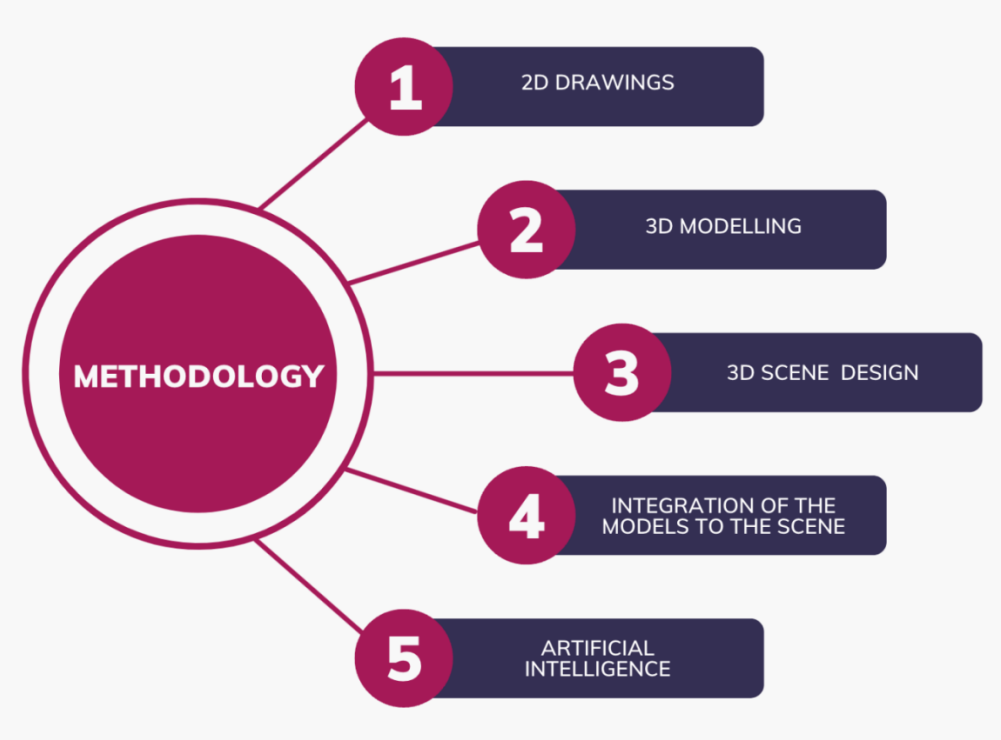
Utilizing a multidisciplinary approach, Ephesus, the ancient city, undergoes a revival within the virtual domain. The process commences with the meticulous creation of 2D architectural drawings, these 2D drawings serve as foundational elements (Tytarenko et al. 2023).

Transitioning seamlessly, the endeavor progresses towards 3D modeling, a pivotal stage characterized by the conversion of two-dimensional sketches into immersive digital recreations. Employing advanced software tools such as 3ds Max® and Blender®, 2D drawings of Ephesus's landmark buildings are meticulously transposed into the digital realm, maintaining fidelity to real-world proportions and details.

Further, the Unreal Engine® serves as the platform for integrating these 3D models into a cohesive digital landscape reflective of Ephesus's geographical context. Drawing from meticulously researched data, a virtual representation of

Ephesus's terrain is constructed, providing users with an authentic backdrop for exploration.

Figure 1. *Workflow of the Methodology*



Integrating artificial intelligence (AI) adds an immersive layer to the experience, as avatars imbued with Ephesian knowledge facilitate interactive engagement. Users are invited to navigate through Ephesus's digital streets, interacting with AI companions to uncover the city's historical treasures, from the iconic Artemis Temple to the scholarly enclave of the Celsus Library.

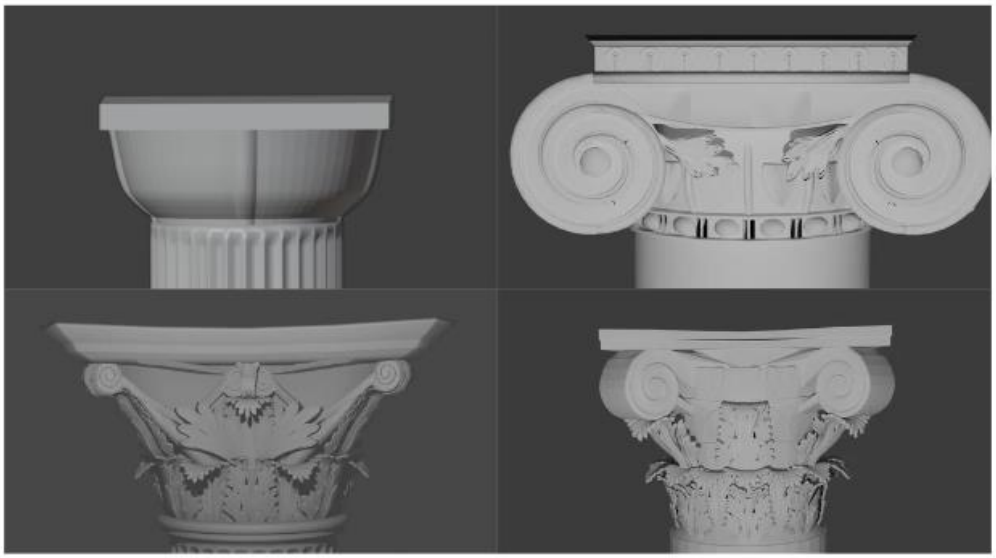
Through the seamless integration of these methodological approaches as displayed in Figure 1, a compelling narrative of temporal exploration emerges, offering users an immersive journey through Ephesus's storied past.

Three-Dimensional Modeling

Columns and Capitals

Figure 2. *(a) Doric Column, (b) Ionic Column, (b) Corinthian Column, (c) Composite Column*

Figure 3. *(a) Doric Capital, (b) Ionic Capital, (b) Corinthian Capital, (c) Composite Capital*



Four types of columns, namely Doric, Corinthian, Ionic, and Composite columns were used in Ephesus, as shown in Figure 2 and Figure 3. In this project columns

were reconstructed to match their real-life counterparts. Ionic capital helixes, which made two curls around the oculus, were made in 3ds Max®. A rectangular box was built with helixes at the edges. Helix interconnection was done in 3ds Max®. Top symbols were produced using sphere, box, and tube commands and modified vertices. The center tubes were built and positioned around the column using the radial array tool. Blender® was used to precisely create the center flower creations. Subordinate symbols were built in 3ds Max®, and compact symbols using circle, sphere, and box methods thus, the ionic column capital is completed. Corinthian columns were created in Blender® for the Project's second column. From a circular base, a cylinder was pulled upward. A box with curled center sides was placed on top. The higher helix supports were built from the helix, while the lower foliage was utilized. To link the helix to the column, the lateral component was attached and shaped with a box. Eight main holders were lateral holders. Finally, leaves were inserted at helix intersections. The final column is a hybrid of ionic and Corinthian columns with Blender®-created headings. It was set for 2 revolutions. After providing the helix form, the cylinder was gently pushed to finish it. A circular structure was built to house the helixes. The box was circularized throughout this operation. The blender® software creates precise floral representations placed in a circle around the focal component. A square with vertices and edge connections was placed on the circular framework. The helix was connected to the structure above it. A box function structure was used to secure the connection. Finally, additional flower motifs were placed on the helixes. The body part of each column is cylindrical. Subtraction was employed to create body protrusions for particular columns. In addition, a miniature cylinder was put around the larger cylinder's end and beginning. Multiple bottom boxes were created using the box function. Blender® and 3ds Max® were used to modify box vertices. The specified column subset was obtained.

Statues

The process of creating statues in Blender® involves the use of many tools such as crease, fill, smooth, draw, scrape, and grab. References indicate that fundamental forms are included. For basic modeling, simple geometric forms such as cubes for the torso, legs, arms, and hands, cylinders for the neck, and spheres for the head are used. Following the first modeling, the use of the crease and draw tools is employed to add preliminary drawing elements. Using the grab tool, intricate elements such as fingers are meticulously crafted. Additionally, the realism of the fingers is enhanced by the use of the scrape tool to add further detail. Once the remaining gaps in some delicate areas have been filled, the smooth tool is utilized to ensure that the details are level with the rest of the body. Once the foundational structure of the statue is complete, the facial features and clothing details are sculpted using a crease tool. Following a thorough examination of each aspect, the sculptures are reassembled (Figure 4 and Figure 5).

Figure 4. *(a) Sophia (Wisdom), (b) Ennoia (Thought), (c) Episteme (Knowledge), (d) Arete (Bravery)*

Figure 5. *The Emperor Trajan*

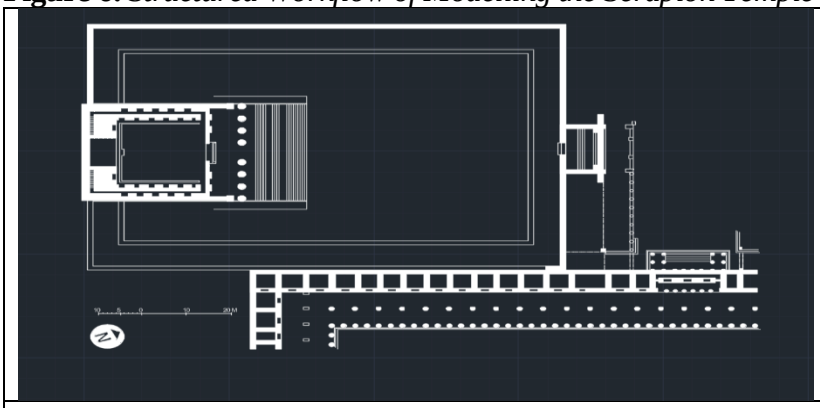
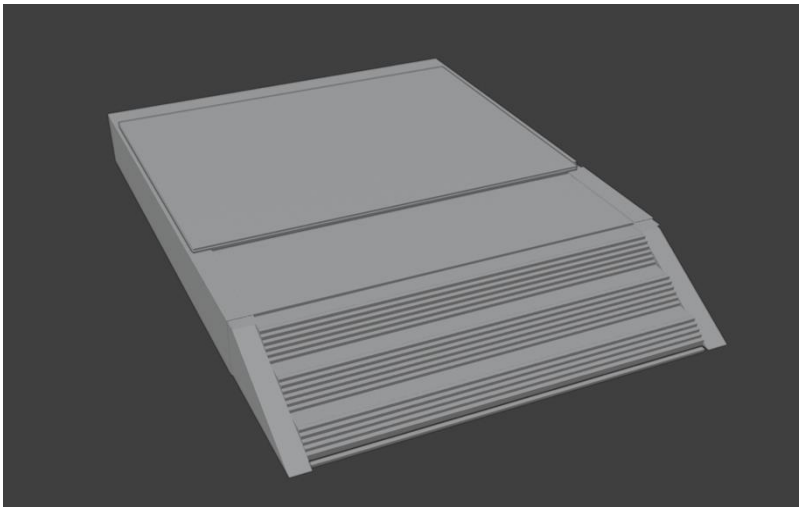
Three-Dimensional Buildings

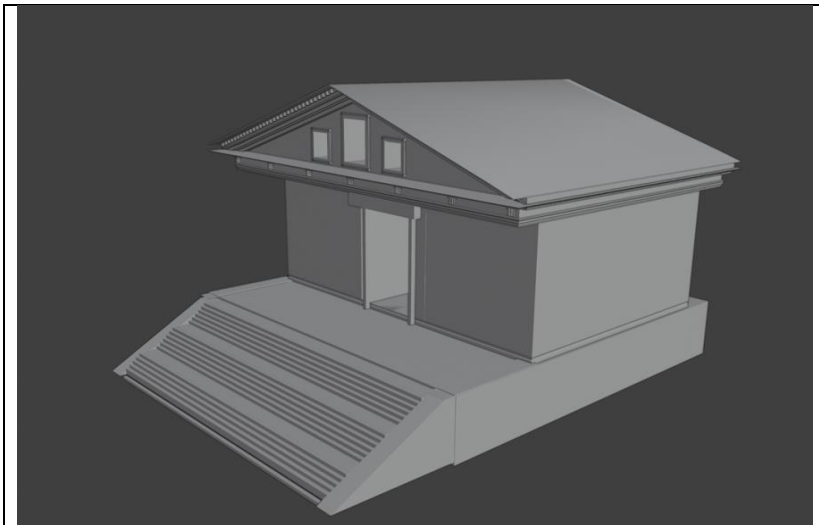
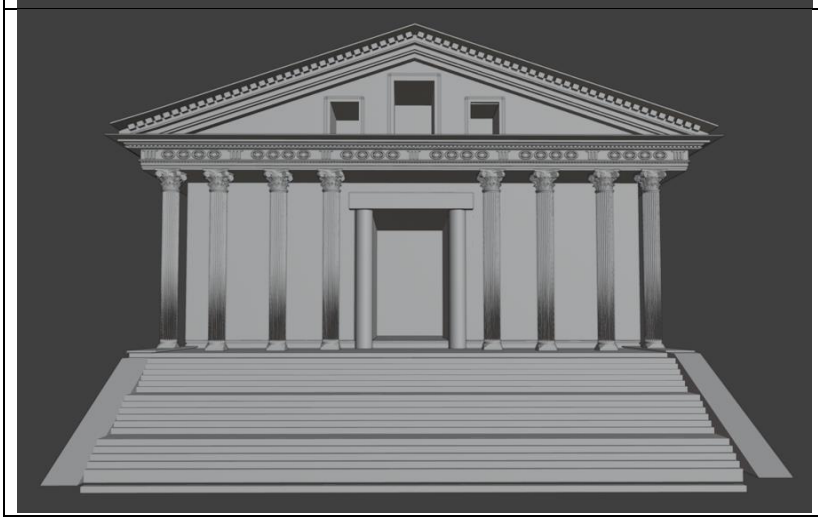
The project has employed 3D modeling to vividly recreate Ephesus in the virtual world. The method of modeling has been identified as the best option when compared to the current architectural modeling, as it aims to maintain the allure and magnificence of Ephesus during its golden era. The distinction between 3D modeling and architectural modeling lies in their degree of abstraction. Architectural modeling provides a greater degree of abstraction, while 3D modeling yields a more intricate and detailed outcome. The most crucial difference between 3D modeling and architectural modeling is that 3D modeling provides an opportunity for backward-looking modeling, while architectural modeling focuses more on forward-looking modeling. Thus,3D modeling has been found to be the most effective method for virtual world modeling, as it allows for a comprehensive understanding of the complex details of the ancient city of Ephesus. Architectural modeling may not be sufficient when trying to design a magnificent city like Ephesus, which is abundant in intricate particulars.

The 3D modelling efforts in this project are a culmination of resources with computer graphics technology. 3D models demonstrate an exquisite combination of historical importance, technical skill, and artistic delicacy in the original buildings. Every building, including the World Wonder Artemis Temple, the iconic Celsus Library, the colossal Grand Theatre, and the elegant Hadrian Gate, displays a combination of design principles and craftsmanship of the time they were built.

In the context of this project, the methodology employed for digitally reconstructing buildings in three dimensions followed a standardized procedure.

Figure 6. *Structured Workflow of Modelling the Serapion Temple*

	2D drawing of the model
	Base of the 3D model

	Model erected from the base
	Completed 3D model

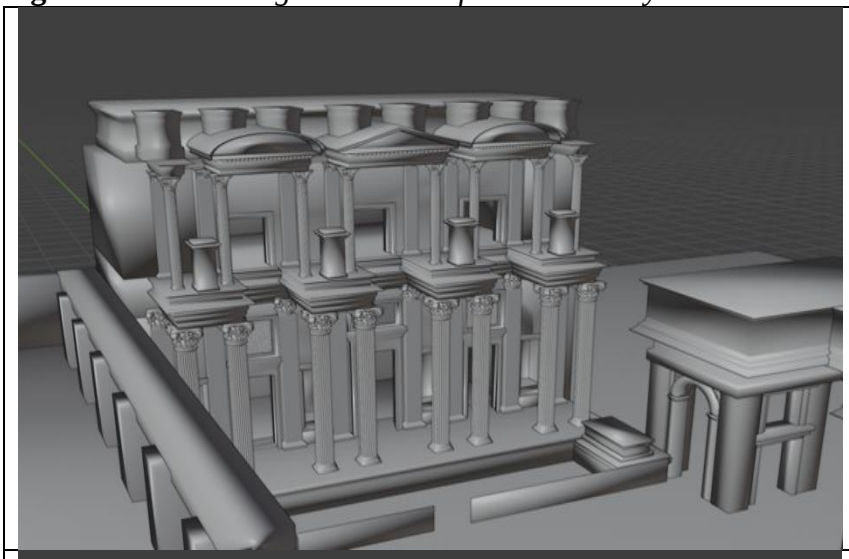
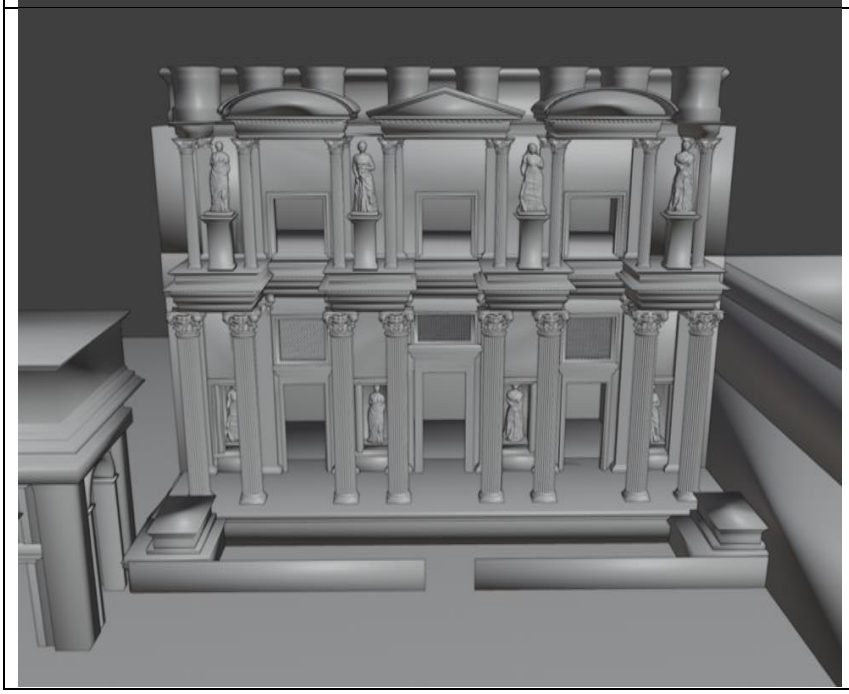
We will demonstrate the procedural steps of modelling by taking the Serapion temple as a case study. These steps are shown in Figure 6. Initially, two-dimensional (2D) drawings were carefully drawn. Subsequently, via these 2D drawings, the construction of the buildings in three-dimensional (3D) space began.

Firstly, the foundation of the structure was established utilizing the box command within the 3D spatial environment. Secondly, attention was directed towards the central segment of the temple. This phase, pivotal due to the distinct characteristics of individual buildings such as statues and columns, required meticulous placement and attention to detail. Finally, to finish the construction process, the roof component was placed into the model.

This methodological approach not only facilitated a structured workflow but also ensured accuracy and precision in the recreation of historical architectural landmarks.

Statues as elements of adornment were used extensively in Ephesian architecture. Celcus library is one of the outstanding examples of this. The 3D modelling in this case required two additional stages, building statue models and placing them in their proper locations (Figure 7).

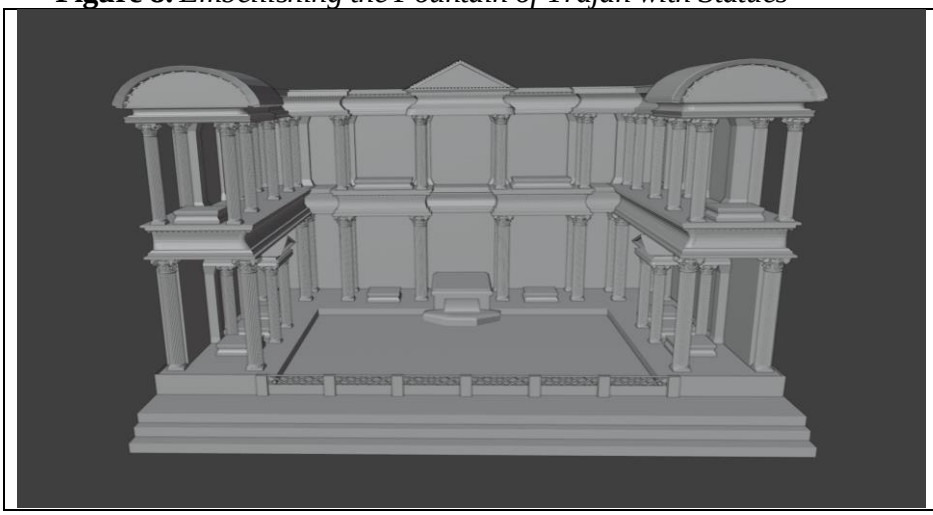
Figure 7. *Embellishing the Facade of Celsus Library with Statues*

	Library of Celsus in the absence of its statues
	The statues peculiar to the library of Celsus
	Final model of the Celsus library

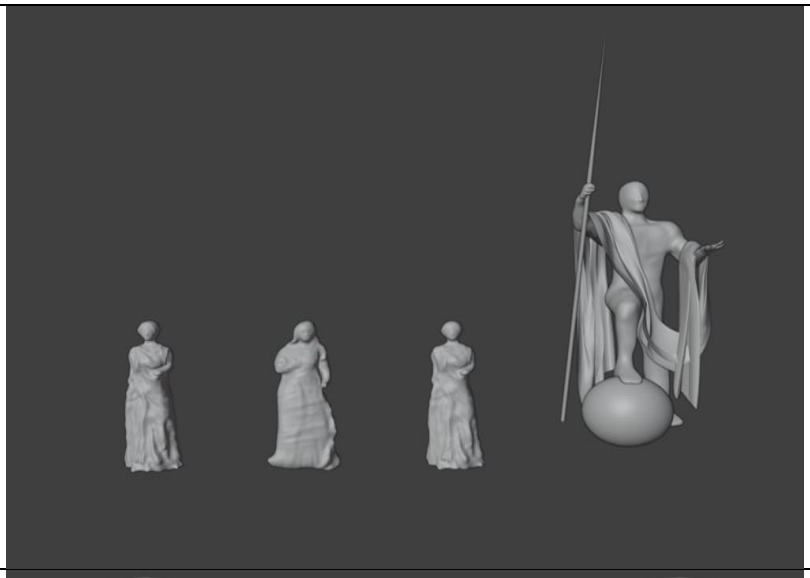
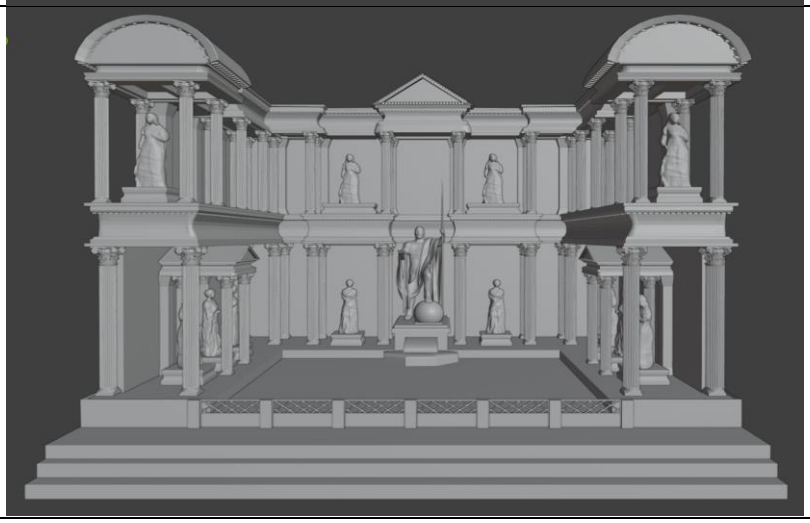
The Library of Celsus is a remarkable structure in Ephesus with a two-story facade and a vast, domed interior measuring 10.90-16.70 meters in length. It is adequately protected from moisture since it is surrounded by an extra wall (*Library of Celsus in Ephesus* 2019). The Celsus Library was designed using various tools and techniques to create a virtual world (Figure 7). The base structure consisted of windows and doors, created using the line command and a bevel profile. A box was used to create the depths of these windows and doors, and the subtraction command was used to finalize the windows and doors. The missing roof part was created using a rectangular-shaped roof, with three minor roofs connected to it. The triangular-shaped roof was created using cylinder and tube commands. The middle part of the library featured columns, and the adjacent buildings were built using the box command for the base structure and the roof. The gate between the building and the library was scaled down using the tube command for the passageway. The stairs at the side of the library were created using a box to make a height difference, and the straight stairs command was used to finalize the side building. Corinthian columns were added using the array command.

Another remarkable of embellishment with statues is The Fountain of Trajan was unique due to the placement of statues throughout the building (Figure 8).

Figure 8. *Embellishing the Fountain of Trajan with Statues*



The Fountain of Trajan Without the Statues

		The statues that give the Fountain of Trajan its magnificence.
		Completed model of the Fountain of Trajan.

The Temple of Domitian had three levels with semi-circular gates arranged around the temple, with a temple resembling the Serapion temple on the top floor. The Odeon and the Grand Theater have similar architectural structures and were both constructed using the same modeling techniques. However, the staircases are smaller in the Odeon, making it a scaled-down version.

The Grand Ephesus theater, a 145-meter-wide marble building, was previously 30 meters wide and was capable of holding up to 24,000 people (Great Theatre in Ephesus 2019).

The Grand Theatre was designed using a combination of commands and techniques. The stairs were created using the tube command, which allowed for the desired radial stairs look. The staircases were divided into three compartments, and paths were created by transforming the stairs into editable poly. Gates were created using the Boolean function.

The main building of the theatre, where acts were played, consisted of boxes and Ionic columns. The manufacturing process resulted in four buildings, two of which were of varying sizes. Sculptures were attached to these structures and

positioned in the reference direction. Decorations on the first floor were created using the Torus command, with the subtract feature making the middle door more inward and another box subtracted from the box.

The Gate of Hadrian, located at the end of Curetes Street in Ephesus, is a monumental structure dedicated to Emperor Hadrian, a Roman practice when an emperor visited a city. It is said to have been devoted shortly after Hadrian's arrival (Gate of Hadrian's - Ephesus Tours 2013).

The Hadrian Gate was divided into three parts, starting with the foundation using the Box command. The first floor was built using extrude and bevel commands to create a box shape for the base, with columns placed on it. The second floor contained an arch-like structure, and multiple boxes were placed for the connection between the second and third floors. The roof was decorated with boxes using the Box command.

The Prytaneion functioned as the administrative edifice or town headquarters. This location served as the venue for religious ceremonies, official receptions, and (Prytaneion - Ephesus Turkey 2024). The Prytaneion is a structure enclosing an area with four walls and containing a temple at its center

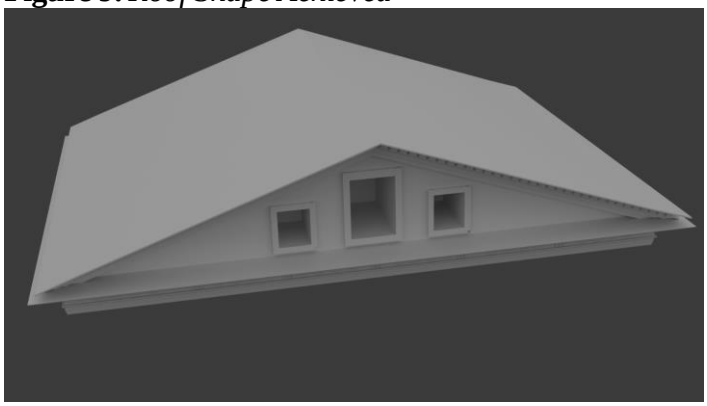
The Temple of Hadrian stands out due to its unique shape of entrance the construction of this temple was completed with the methods previously mentioned. The Octagon, a smaller building, had octagonal steps leading to the central area surrounded by Corinthian columns. The Memnius Monument was constructed using the box command to construct the foundational staircase, followed by the four primary columns. The Heron of Androklos was a two-story structure with rectangular columns on the side and ionic columns as load-bearing pillars for the roof.

The Temple of Artemis was built with such care and craftsmanship and budget had become the symbol of Ephesus not only with its huge size but also as the sentinel of Ionian style. The building had unique statues and many columns. This temple was the outcome of the greatness and wealth of the city in its days. The Temple of Artemis was regarded as one of the seven wonders of the world. The Temple was adorned with a multitude of Ionic columns. A large golden statue of Artemis was positioned in the center of the temple also two uniquely built statues of the wounded amazon and lying women is located on the roof of the Temple of Artemis. There is a continuous arrangement of statue models encircling the buildings, located between the triangular roof and column heads.

Roof Shape

In constructing this project according to the reference pictures, it was realized some models were similar to each other, so to begin with the modeling of the buildings. The team discussed these similar structures and how to draw them. For instance, the roof modeling in this project was used in different buildings to achieve the desired roof shape, identical to the reference picture. Firstly, a box was placed with the correct size, and the vertices of the box were increased to be pulled up from the middle vertices to create the desired triangular shape. This methodology was used in similar roof structures throughout this project as seen in Figure 9.

Figure 9. *Roof Shape Achieved*

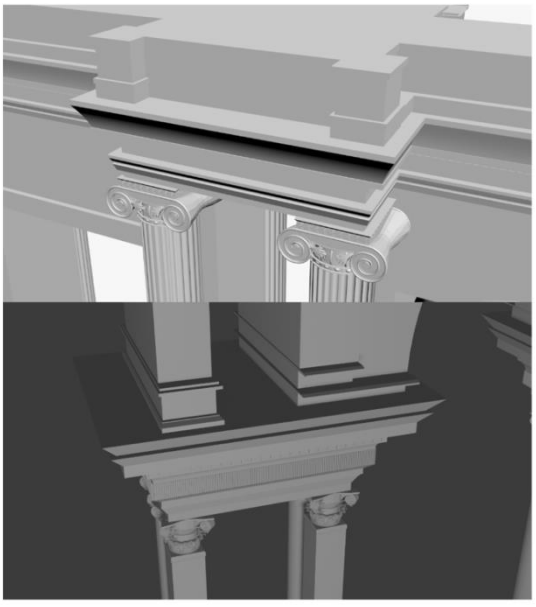


Connection Parts

The most repeating methodology in this project was manipulating a box using the bevel and extrude commands to create the shape. This shape was sometimes used in the base of a structure, or this shape was used to connect or divide the sections in the building. This method can be seen in nearly every building.

To create the shape as seen in Figure 10, they are similar to each other; they share the same steps but differ in the details; this shape has been achieved by using the extrude command to give the box a bit of height as desired on the y-axis and to create the widening look bevel command with the desired height and widening settings this shape has been achieved.

Figure 10. *Connections Part, (a) From the Harbor Gate, (b) from the Hadrians Gate*



Unreal Engine® Level Design

Height Map

The Skylines was obtained by downloading it from a website called Map Generator. The position of Ephesus was determined and certain specifications were set, such as a map size of 15 km, a height scale of 100%, a water depth of 30m, and a waterside slope of 16. The required modifications were made accordingly. Once the download was completed, it was loaded into the Unreal Engine® software. Once the required adjustments and modifications were made to the height map, it became prepared for use.

Lighting

In order to achieve a realistic level of illumination across the entire region, the sun sky lighting tool incorporated into Unreal Engine® was utilized. This technique was utilized in order to achieve a realistic illumination of the map.

Material

Regarding the Material aspect, the necessary materials were sourced from Quixel Bridge for the project. Many varieties of marble and concrete materials in a range of varied colors were discovered. After the colors, transparency, and pattern of the material tones were manipulated using the Unreal Engine® blueprint, they were prepared to achieve the required form.

Foliage

The foliage component was sourced from the Unreal Marketplace by Epic Games®. The oak, pine, and low poly trees were the primary subjects of the examination. An examination of a low poly tree is being done with the intention of improving rendering speed. Changes were made to the features of the tree species that were identified in order to make them consistent with the map. These changes included adjustments to their size and density.

Water

The water plugin that was given by Unreal Engine® was used for the element of the project that dealt with water. The water that was supposed to be used was modified so that it corresponded to the actual water regions that were situated around the city of Ephesus.

Artificial Intelligence Implementation

The user interaction with the city and the level of immersiveness has been enhanced through the AI component. AI component also serves to elevate the influence of the ancient city of Ephesus on the user. The goal is to offer the user an exceptionally interactive and educational experience through the use of artificial intelligence. The user has the ability to halt the Ephesians, who are roaming around the ancient city, in order to gain knowledge about the modeled buildings and the historical aspects of the city. How the AI component has been incorporated into this project is briefly explained below.

Creating an avatar that models each team member is the fundamental stage to adding an AI component to the project. The steps of this stage are shown in Figure 11, and briefly explained below:

Initially, an original avatar was generated using the MetaHuman Creator®. This was followed by giving attributes to this character by using the Convai® site. In addition, the backstory of the character, and knowledge bank are integrated at this site.

Subsequently, the MetaHuman® character was imported to the project. Afterward, the Convai® was plugged into Unreal Engine 5®. After the plug-in was done, the Convai® character was selected from the avatar class, the Convai® API Key was entered into the Unreal Engine® project settings. Matching the AI ID created from the Convai® site with the Metahuman® previously imported into the project.

This character's appearance was modified to resemble real-life counterparts of the project team members and then imported into the Unreal Engine®,

In summary, an avatar was generated using the Convai® site. Responsibilities such as creating a story and a knowledge bank were assigned to this avatar. To integrate the Convai® avatar with the MetaHuman® avatar, the Convai® plugin was included in the Unreal Engine®, allowing the two avatars to be combined using the resultant character ID. Following the merging procedure, the blueprints of our character were merged with the Manny mannequin in the Unreal Engine®, equipping the mannequin with the ability to perform running, walking, and jumping actions.

Figure 13 shows the creation of an avatar resembling a team member and in Figure 12 the created avatar is in front of the Temple of Artemis. This avatar is able to roam in the scene and engage in dialogues.

Figure 11. *AI Methodology Chart*

Figure 12. *Avatar in Front of the Temple of Artemis*

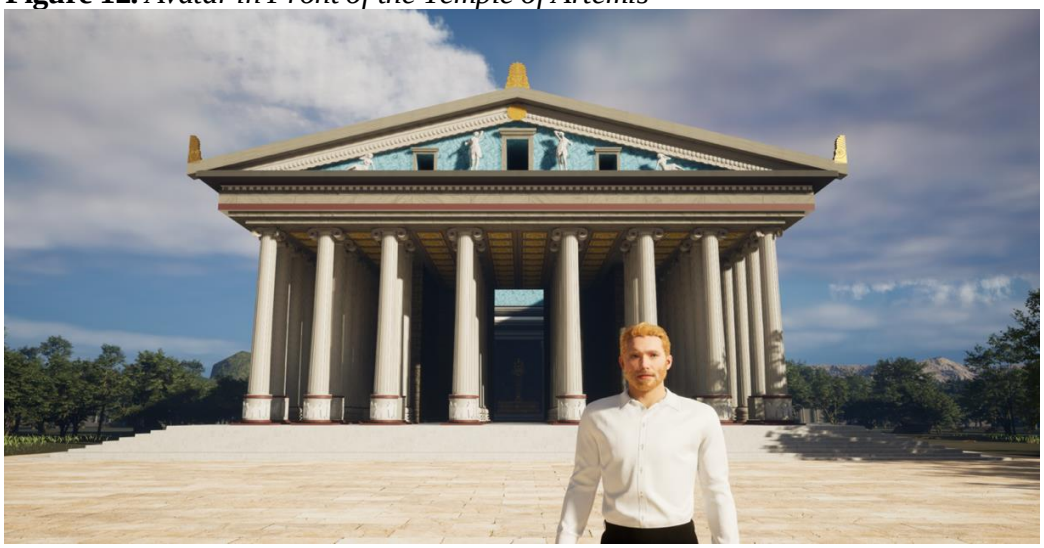
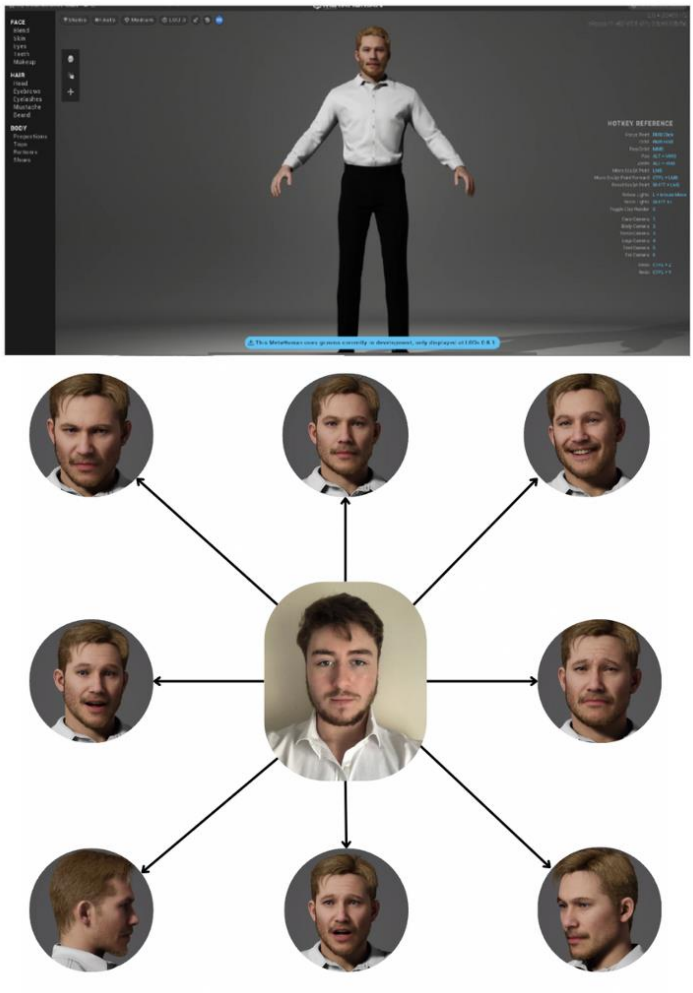


Figure 13. *Avatar Creation*



Results

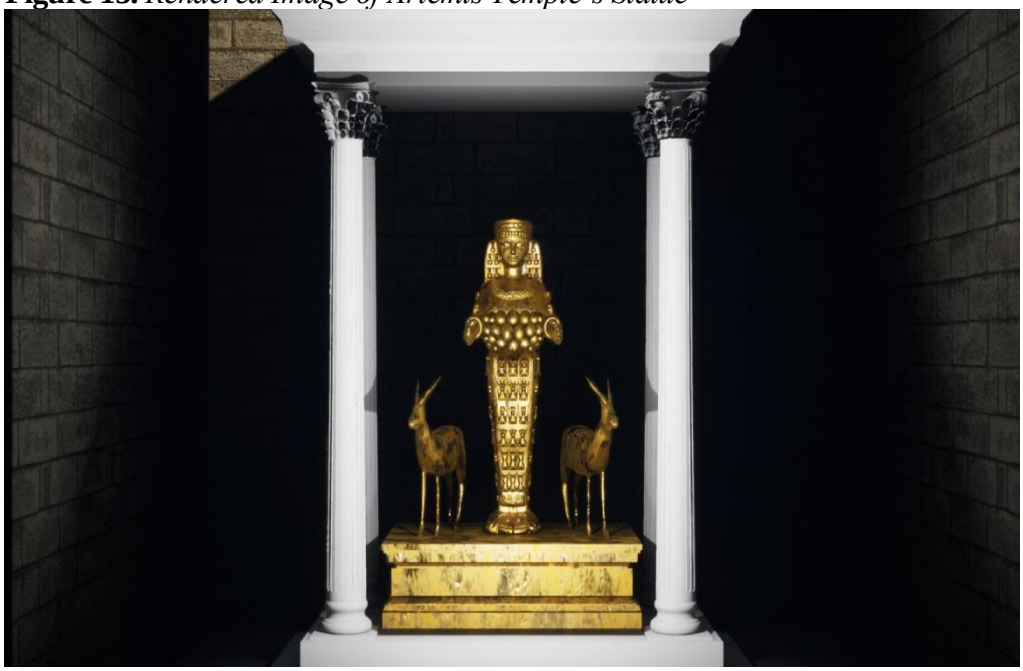
The results of showcase in this section are the outputs of Unreal Engine 5®. As mentioned before, geographical features such as trees, lighting and water were edited. Each building was carefully placed on the map to reflect the beauty and grandeur of the ancient city of Ephesus as it had once been. The results are a combination of the models, the map, and the avatars, inviting the user to take a time travel through the streets of Ephesus. 3D models serve as a connection between space and time (Parrinello et al. 2018). This combinational result brings the magic of the ancient city to the present day visitor. Thanks to the results, the sophistication and cultural, architectural, etc. factors of the ancient city continue to intrigue the minds and hearts of today's researchers and visitors even centuries later. The figures shown in this section depict in detail some of the most prominent buildings of Ephesus, from the Temple of Artemis to the library of Celsus. In addition, a sophisticated educational dialogue between the user and the artificial intelligence unique to the project is shown about the temple of Artemis.

Overall, the project embodies an innovative and distinct method of historical education and involvement by incorporating artificial intelligence. Through establishing dynamic engagement between users and virtual avatars, the application provides users with an unusual chance to explore and comprehensively grasp the Ephesian history with detail.

Figure 14. *Rendered Image of Artemis Temple*

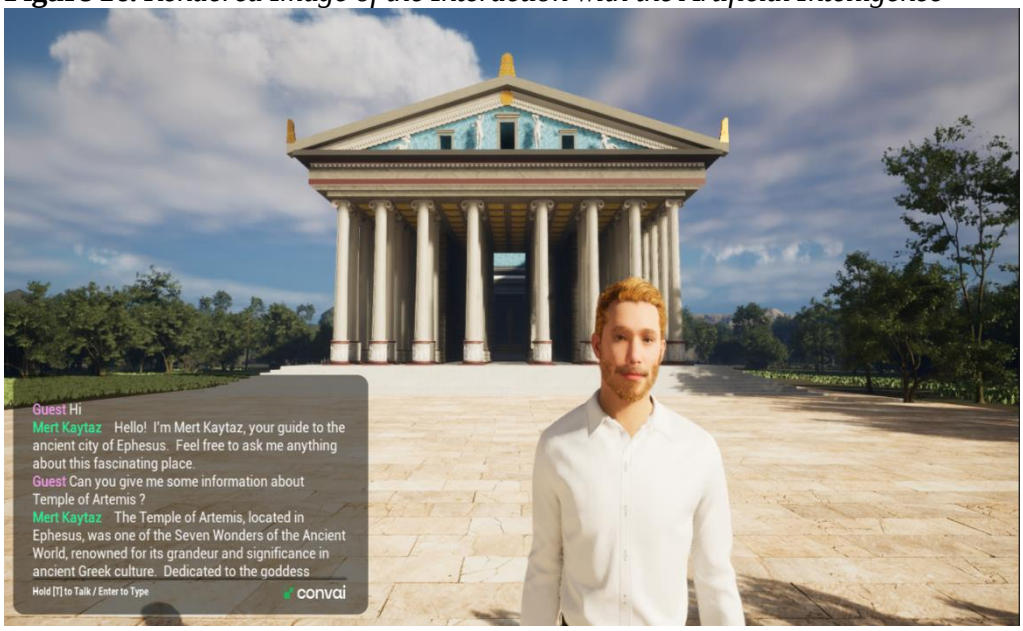
Figure 14 showcases a rendered image of the Temple of Artemis located in the Ephesus map. In this image, it is visible to feel the magnificent beauty of the Artemis Temple.

Figure 15. *Rendered Image of Artemis Temple's Statue*



In Figure 15, there is a rendered image of the statue centered inside the Temple of Artemis (*Denker* 2024).

Figure 16. *Rendered Image of the Interaction with the Artificial Intelligence*



In Figure 16 the guest is in front of the Artemis Temple demanding information about the temple by asking questions to the implemented artificial intelligence. The guest can learn about the history behind the buildings surrounding the Ephesus simply by asking questions to the artificial intelligence.

Figure 17. *Rendered Image of the City's Entrance*

Figure 17 captures the entrance of the Ephesus as seen through the Harbor Gate coming ships enter the city.

Figure 18. *Rendered Images of Heroon of Androklos and the Octagon*

In Figure 18 detailed results of Heroon of Androklos and the Octagon can be seen.

Figure 19. *Perspective View of the City from the Grand Theatre*

In Figure 19, a perspective view from the Grand Theatre is captured as the visitor is sitting in seats of the Theater seeing other attraction sites at the horizon. For instance, the Arcadian Way, the Agora, Hadrian Gate, Harbor Gate, and The Prythaneion.

Figure 20. *Rendered Image of the City from the Celsus Library*

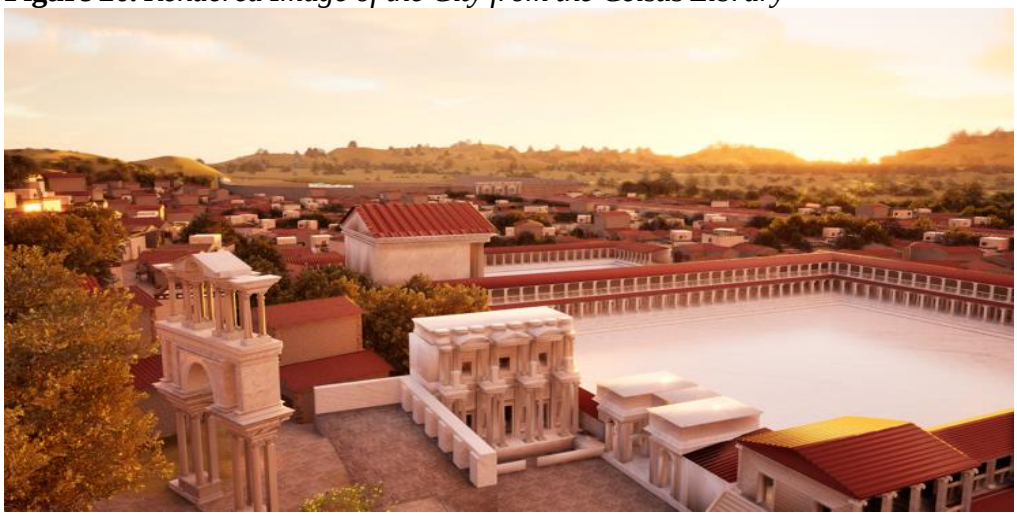


Figure 20 captures the beauty of the Celsus Library alongside with other beautiful structures such as the Hadrian Gate, the Agora, and The Prythaneion.

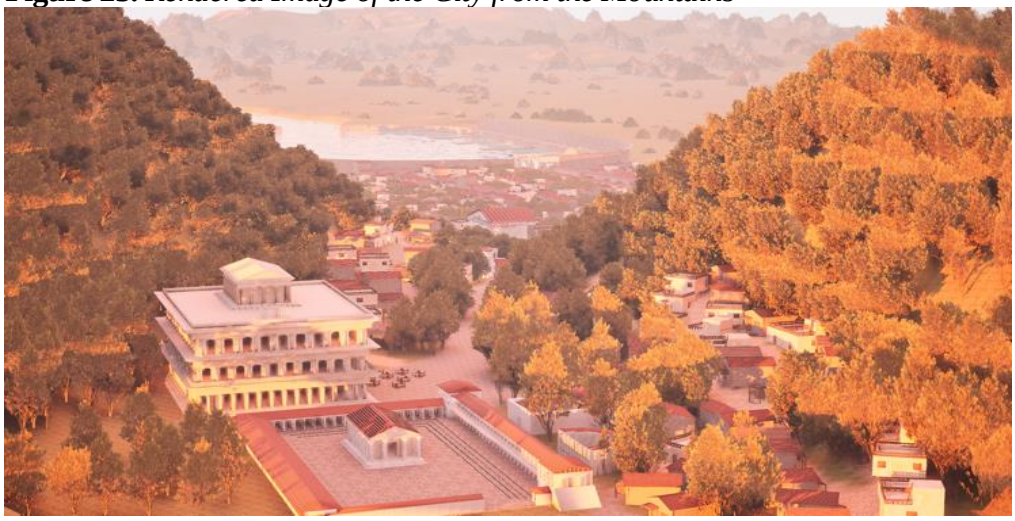
Figure 21. *Rendered Image of the City from the Bird's Eye View*

Figure 21 displays Ephesus' stunning beauty from a bird's-eye view, showing its entire area from mountains to sea.

Figure 22. *Rendered Image of the Fountain of Trajan*

In Figure 22 finished version of the Fountain of Trajan can be seen with its unique statues.

Figure 23. *Rendered Image of the City from the Mountains*



In Figure 23, the Ancient City of Ephesus is shown from the mountains. The State Agora, Odeon, and Temple of Domitian can be seen.

Figure 24. *Rendered Image of the Serapion Temple*

In Figure 24, the finished version of the Serapion Temple is displayed.

Figure 25. *Rendered Image of the Arcadian Way*

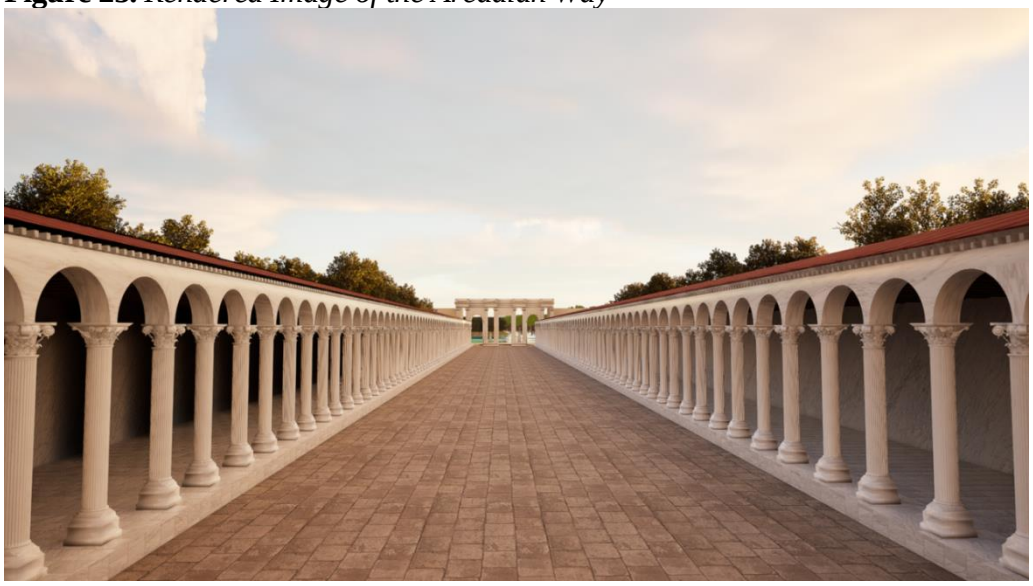


Figure 25 depicts the Arcadian way to the Harbor Gate, which leads to the seaside of the city.

Figure 26. *Rendered Image of the Harbor Gate*

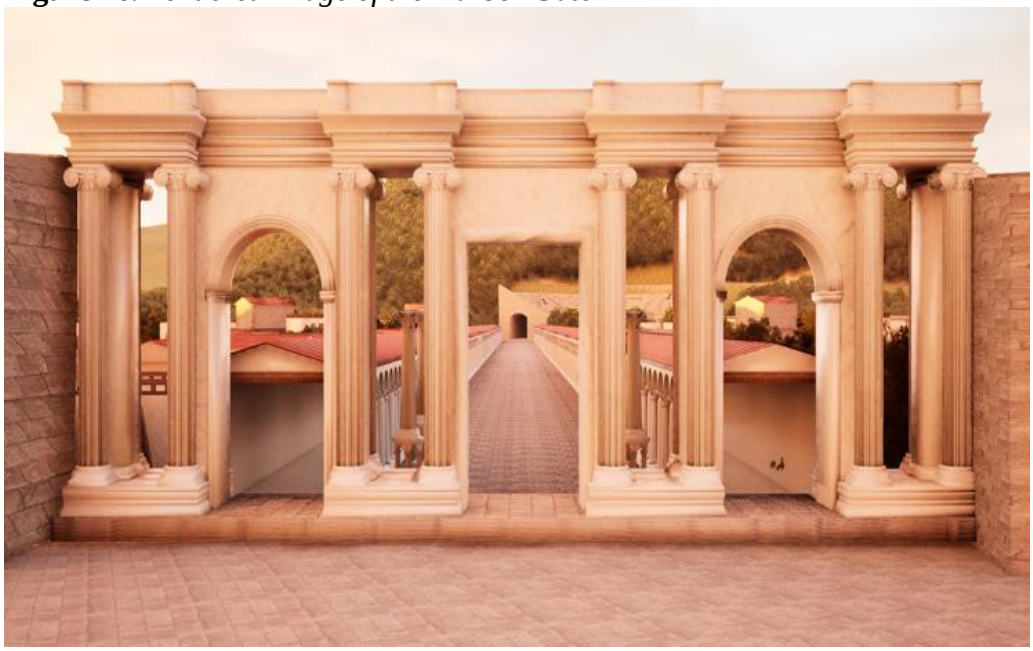


Figure 26 portrays the Harbor Gate, which serves as the entrance to the city.

Figure 27. *Rendered Image of the Hadrian Temple*

Figure 27 displays the rendered image of the Hadrian Temple.

Figure 28. *Rendered Image of the Odeon*

Figure 28 provides the rendered image of the Odeon next to the state Agora.

Figure 29. *Rendered Image of the Memnius Monument*

Figure 29 provides the rendered image of the Memnius Monument.

Figure 30. *Rendered Image of the Prytaneion*

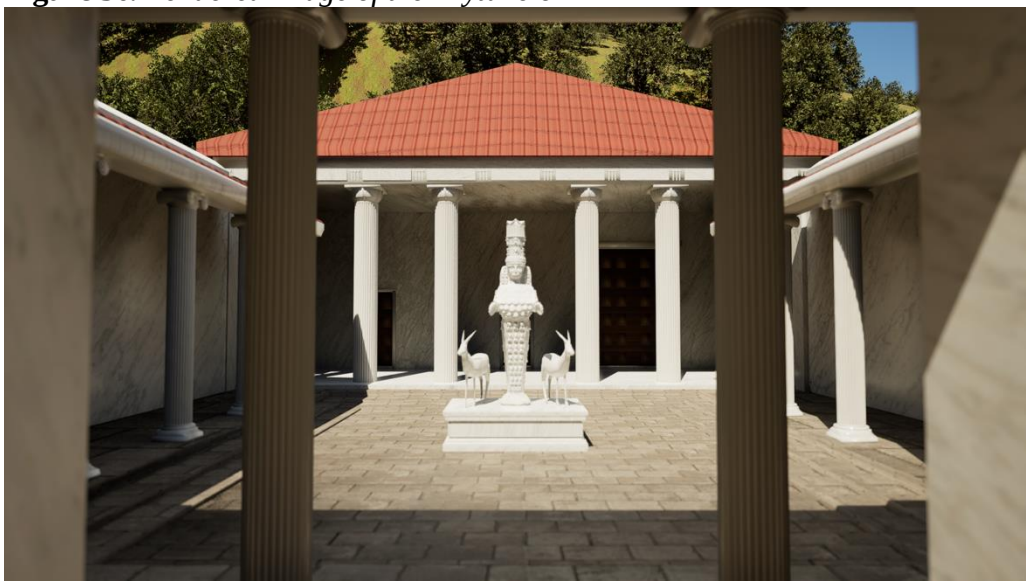


Figure 30 provides the rendered image of the *Prytaneion.*

Discussion

The endeavor to digitally resurrect the ancient city of Ephesus stands at the intersection of historical scholarship and technological innovation, presenting a compelling glimpse into the past using advanced methods. Ephesus, once a thriving metropolis in the heart of Asia Minor, held multifaceted significance as an economic center, political capital, and religious sanctuary. Its legacy, intertwined with the rise and fall of empires, continues to captivate scholars and enthusiasts alike.

The methodology intricately wove together various disciplines, beginning with 2D reconstructions based on archaeological findings and historical records. These foundational drawings served as blueprints for the intricate 3D models meticulously built using state-of-the-art software tools like Blender® and 3ds Max®. The transition from two-dimensional sketches to lifelike digital replicas was a crucial step in breathing life into the virtual rendition of Ephesus.

With the aid of Unreal Engine®, the digital models were seamlessly integrated into the geographical landscape of Ephesus, recreating its ancient topography with precision. This integration not only provided a visually immersive experience but also facilitated a deeper understanding of the city's layout and architectural marvels.

A significant aspect of the project lies in the integration of artificial intelligence (AI) to enhance user interaction within the virtual realm. By imbuing AI avatars with historical knowledge and contextual information, users are guided through the streets of ancient Ephesus, encountering iconic landmarks and engaging in immersive educational experiences. This dynamic interaction fosters a deeper appreciation for Ephesus' cultural heritage and historical significance.

Looking forward, the incorporation of extended reality (XR) presents exciting avenues for future exploration and enhancement of the virtual Ephesus experience.

XR technologies, encompassing virtual reality (VR) offer unparalleled opportunities to further immerse users in the rich tapestry of Ephesian history. From interactive archaeological simulations to educational gaming experiences, XR holds immense potential for expanding the boundaries of digital heritage preservation and public engagement.

In conclusion, the virtual resurrection of Ephesus represents a harmonious blend of historical scholarship and technological ingenuity, offering a captivating journey through time and space. As scholars continue to push the boundaries of digital reconstruction and immersive storytelling, Ephesus remains a testament to the enduring allure of the ancient world in the digital age. Through XR and beyond, the legacy of Ephesus will continue to inspire and educate generations to come.

Conclusion

In this project, Ephesus comes alive in a never-before-seen experience, where the ancient city's essence is brought to the virtual realm. A thorough examination of historical literature and 150 years of excavation results sets the stage, providing a foundation for understanding Ephesus' physicality during its peak in the second and third centuries. This scholarly endeavor lays the groundwork for creating two-dimensional drawings, opening the gate to three-dimensional modeling.

Leveraging advanced software like Blender® and 3ds Max®, each architectural marvel is meticulously modeled, ensuring a faithful reconstruction for every landmark building. Statues and columns, emblematic of Ephesian architecture, are modeled and added to the buildings with precision. Their placement within the modeled buildings enhanced the visual quality of the 3D reconstruction results. Powered by the Unreal Engine®, the visual components of Ephesus are brought to life, from the intricate architectural details to the ambient lighting, shimmering waters of the harbor, and lush foliage surrounding the city.

An interactive dimension is inserted through the insertion of an artificial intelligence component. This enables users to engage with knowledgeable avatars freely roaming the virtual landscape of Ephesus.

Users embark on a captivating journey through time as guests. They traverse the enchanting streets of Ephesus, encounter Ephesians and iconic landmarks of the city such as the Artemis Temple and the Celsus Library. Via avatars furnished with artificial intelligence acting as virtual tour guides, users immerse themselves in the virtually recreated splendor of Ephesus.

This unparalleled excursion not only entertains but also educates. Use of artificial intelligence offers users a sense of immersion, a deeper understanding of Ephesus. In conclusion, the culmination of meticulous research, advanced technology, and creative vision converges to deliver a captivating and immersive experience of Ephesus like never before.

References

Corcini L, Medeiros L, Moser A (2016) *Changing ways for a better education: A 3D gamified virtual learning environment (VLE)*. Athens: ATINER's Conference Paper Series, No: EDU2016-1945.

Denker A (2023) *Bringing visibility to the original splendour of a lost wonder of the ancient world: the temple of artemis at ephesus*. ISPRS Annals of the Photogrammetry, Remote Sensing and Spatial Information Sciences.

Denker, A. (2024) Klasik Çağ'ın Kaybolan Harikası: Artemis Tapınağı, Tarihçesi, Mimarisi ve Dijital Rekonstrüksiyonu (The Lost Wonder of the Classical Age: The Temple of Artemis, Its History, Architecture, and Digital Reconstruction). İstanbul: İstanbul Bilgi Üniversitesi Yayınları.

Denker A, Fangi G, Silver M (2018) *Reviving Palmyra in multiple dimensions: Images, ruins and cultural memory*. Caithness, Scotland: Whittles Publishing.

Gate of Hadrian's - Ephesus Tours (2013) *Ephesus Tours.* Available at: http://www.ephesustours guide.com/ephesus/gate-of-hadrians.

Great Theatre in Ephesus (2019) *Turkish Archaeological News*. Available at: https://turkisharchaeonews.net/object/great-theatre-ephesus.

Highlights of Ephesus (n.d.) *Google Books*. Available at: https://books.google.com.tr/books?hl=tr&lr=&id=iBb5EAAAQBAJ&oi=fnd&pg=PA2&dq=re+building+ephesus&ots=2GUbe3Hz-7&sig=cI88OWRlS4V_Gdx3jhlKB7NW_L0&redir_esc=y#v=onepage&q=re%20building%20ephesus&f=false.

Hill S (1999) *Ephesos: 100 Jahre österreichische Forschungen.* (Ephesus: 100 Years of Austrian Research). The Classical Review 49(2): 615–615.

Library of Celsus (n.d.) *Through Eternity*. Available at: https://cms.throughetternity.com/upload/ CONF83/20230709/BlogEphLibrary.png.

Parrinello S, Picchio F, Becherini P, De Marco R (2018) The Drawn Landscape in 3D Databases: The Management of Complexity and Representation in the Historical City. *Athens Journal of Architecture* 4(3): 299–322.

Prytaneion - Ephesus Turkey (2024) *Ephesus Turkey*. Available at: https://www.ephesusturkey.com/ephesus-highlights/prytaneion/.

Quatember U (2010) The "Temple of Hadrian" on Curetes Street in Ephesus: new research into its building history. *Journal of Roman Archaeology* 23: 376–394.

Tytarenko I, Pavlenko I, Dreval I (2023) 3D modeling of a virtual built environment using digital tools: Kilburun Fortress case study. *Applied Sciences* 13(3): 1577.