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3D Virtual Experience with a Transformation of the Historical Canadian Fortress in the Latest Technology

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Abstract: The paper examines thoroughly how utilizing the latest technology, such as a PC (personal computer), an iPad, or an iPhone, can entertain many people and allow them to learn about the archaeological findings that have become broadly available through the application of new technology. The paper assesses web usage through the difference in availability and convenience of PC and compact devices by connection to 3D augmented reality applications. Modern technology has allowed access to this information to become radically altered, whereas historical records and remains are dwindling. However, the development of 3D technology means that the general public can experientially pursue the dignity of historical buildings. It also becomes easier through the use of the latest technology to decipher the effectiveness of people's interaction with inclusive descriptions of the documentation. This research aims at verifying the visualization of Fort Frontenac by the use of a chronological renovation process. This paper is composed of five elements: an introduction, the historical records about the necessity of 3D modeling, heritage visualization by means of 3D modeling, web design, and iPad and iPhone usage, a comparison of the architectural change that occurred in the restoration of Fort Frontenac, and conclusions.

Key words: Heritage visualization, 3D computer graphics, interactive virtual design, web design, iPad and iPhone use.

1. Introduction

The aim of this project was to focus on how to compare the effective use of most representative technological devices, such as a computer and an iPad, which are prevalently used in modern times, to traditional research and heritage visualization and representation done on historic sites. The PC (personal computer) places a computer on the desktop, which can allow a user to watch video clips and interactive sceneries on a webpage. On a wide screen, a PC can give users time to learn the details and depth of history of the chronological changes in the fort's renovation. Compact devices, such as an iPad or an iPhone, were designed to let users flexibly move around a particularly trackable sheet in a 360-degree view generating a 3D augmented reality while having a dynamic and thrilling experience in the middle-age world when Fort Frontenac was erected.

These tasks are difficult because there is limited information and only a small amount of archaeological remains from the original fort. The existing archaeological and historical records regarding Fort Frontenac are limited in their release to the public. When this research was conducted, the Kingston Archaeological Centre had held important exhibitions of the valuable documentation, but the exhibition had already closed, and its reopening looked uncertain. While the original maps and plans of Fort Frontenac are incomplete, a fertile imagination and computer graphics design skills are vital to helping correct false assumptions regarding historical viewpoints. For example, questions need to be asked, such as what were the colors of the buildings? Color may be involved with an overly subjective viewpoint.

Moreover, the 3D restored constructions have the

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advantage of clearly conveying a true picture of the erected fort at that time to not only researchers, but also to various scholars and lay people, in spite of several difficulties. It is also worth scrutinizing the concept that the restored fortress rendered in 3D technology can be broadly delivered to people by means of a website and the use of an iPad or an iPhone.

2. An Expansion and Reinforcement of Fort Frontenac

2.1 Historical Background

Fort Frontenac was an important military fortress for the security of the new colony of Lake Ontario, and the fur trading post that was built in Kingston, Ontario, Canada in 1673, ostensibly to secure the fort as a French trading post, protect the Iroquois, and prevent fur trade by English and Dutch merchants. However, the fort's real purpose was to serve His Majesty the French King, Louis XIV, and to expand French settlement in America through internal exploration and Christian missionaries in favor of smooth trade [1]. The fort was changed four times, initially by replacing the log palings with masonry walls and adding bastions while it was involved in frequent outbreaks of fighting with the Iroquois. When the renovation of the fort was completed, it became a large, impressive building. However, the newly reconstructed edifice was destroyed in 1689, but was then later reconstructed in 1695 to make military activity and accommodation stronger. Over the course of 50 years, the fur trade gradually became more unprofitable, and the fort was conceded to British forces during the Seven Year's War in 1758, who devastated it. The fort was never rebuilt, and was subsequently abandoned because the fortification was no longer needed. New buildings and streets were then erected above its ruins for more than a hundred years. In 1983, archaeological research finally successfully excavated only a small portion of the fort, the northwest bastion (Fig. 1). The fort was designated as a Canadian National Historic Site and a part of the northwest bastion was reconstructed in 1984 [2, 3].

2.2 Situation Analysis

The following main output of this project captured the important features of the fort restoration in chronological order and was then spurred to adapt the results using modern technology. The question was raised about how the features of the outpost could be well adapted in 3D computer graphic software used for modeling and then represented on a website through videos and interactive sceneries, as well as through the use of compact devices for 3D augmented reality.

(1) Changes in the Walls: As time passed, the width of the walls became obviously broader when the fort was being renovated, whereas the height of the walls remained the same. This information resulted

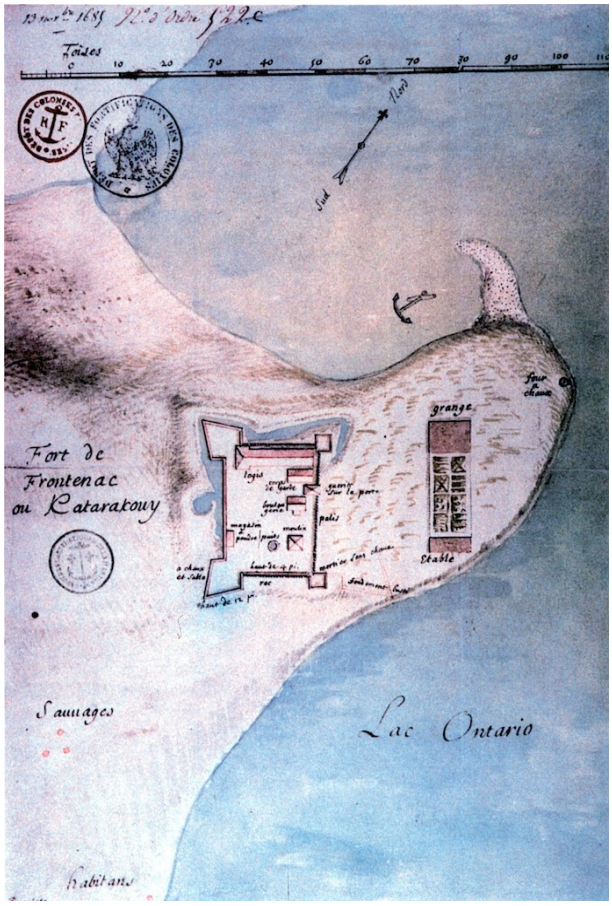

Fig. 1 Old map of surroundings around Fort Frontenac in 1685 © provided by Mrs. Susan Bazely, Copyright 2015 [4].

from a clear relationship between the height and weight of the fortress walls in context to the fact that the fort was constructed for the number of garrisons required. In 1673, there were 400 men who inhabited the fort, including soldiers, traders and French inhabitants, and by 1685, that number had increased to 2,000 men [1]. The number of garrisons was not clear, but the garrisons would have increased in proportion to the total of all of the men participating in the fort [5].

(2) Increases in Buildings: In 1673, the buildings constructed included the following: a well, two storehouses for provisions and ammunitions storage, as well as log palisades whose north and south sides were forty-six feet and whose other sides were twenty feet in length. On the other hand, in 1688, buildings constructed inside the fort included the following: a large tower and four small towers, wooden platforms and scaffolds, a wooden bridge, a masonry gate, and full limestone curtain walls with many casements and loopholes [6]. The increase in the number of buildings which had to be strongly reinforced was due to the improvement of military services and interior exploration. As the number of buildings inside the fort increased, the reinforcement of the buildings also increased and their materials became stronger and more highly qualified for the task.

(3) Outpost: The French tried to make the fort attractive to the native people inhabiting the immediate vicinity of the fort, but the Indians were more interested in the fort's economic purpose for furs and goods rather than the fort's physical presence. They usually passed by the fort for beaver hunts without astonishment [1].

(4) Design Ideation: In order to achieve a true picture of Fort Frontenac as it existed in the past and then allow it to be analyzed and rendered with cutting-edge technology, such as a website and an iPad, meticulous research was required via historical maps, plans, and an examination of the architectural styles of the fort. A physical visit and an archeologist's opinion were more beneficial to enhancing this exceptional research. The dates that this researcher visited Kingston, Canada, were December 3rd, 2013 and September 26th, 2014 (Fig. 2) in order to photograph and glean information about the target fort. Moreover, a consultation with a local archaeologist, Mrs. Susan Bazely, was well worth the opportunity to share her knowledge, and experience in archaeological research, as insights for research development. A good guide for the ensuing 3D modeling using Maya software was to set up to scan drawings and blueprints during this visit.

The following practical software was essential to building models of the fort: Adobe Photoshop, Crazy Bumps, and Autodesk Maya. The exterior of the fortress was constructed in five steps which included the following years: 1673, 1675, 1680, 1685, and 1688. The 3D modeling techniques used included polygon modeling, shading, and lighting. The textures of the buildings were shaded, and the background of the buildings and its surrounding environment were added by lighting adjustment. The completed models were rendered to produce video clips and interactive animations through camera movement, which were set in motion as a 3D camera was placed to create a bird's eye-view and a 360-degree view from the fort [7].

Interactive sceneries in Adobe Flash were devised to provide an effective way to implement visual communication and learning through the use of a mouse. The interactivity was integrated into the 3D

Fig. 2 The remains of Fort Frontenac.

models of the fort with unseen clickable buttons in order to allow the viewer to learn more about the fort's structure and historical importance. The interactive sceneries were imported into the Metaio software for 3D augmented reality that was designed to instantly feature the 3D virtual appearance of the fort building by having the user hover over a photo of the fort's remains and its historical map with an iPad or an iPhone. Additionally, video clips and interactive sceneries were integrated into the website in order to inform the user of the fort's social system and historical events.

3. Process

3.1 Modeling Buildings in Maya

(1) Constructing Buildings and Environment: Maya 2014 is a professional tool that has the means of modeling physical objects and rendering sequences to create animations. By complying with the notes regarding the archaeological and historical consequences of the research, a careful operation was performed in Maya in order to fashion the length, height, and size of each building, including the log palisades, curtain walls, and moats.

In addition, Crazy Bumps is a convenient software program for shading textural materials where photos were simultaneously turned into displacement and normal maps. The software is the most effective, simplest, and easiest way of creating these types of maps, since the software is beneficial to the enhancement of aesthetics and contrast. Four, six, or eight images became two or four of each image by means of flipping the images vertically and horizontally and then stitching the original whole images together with much repetition in Photoshop. The images were offset, and the clone tool was used to make seamless repeating patterns (Figs. 3 and 4). The more images that were put on the one large image in Photoshop, the more realistic the textures of the buildings were when the images were transformed into displacement and normal maps which were

Fig. 3 A displacement map of stitched textures for the fort's curtain wall done in Photoshop.

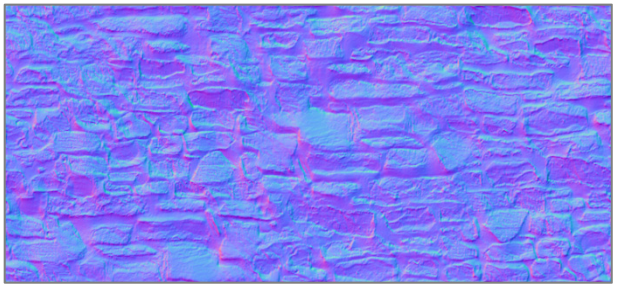

Fig. 4 A normal map of stitched textures for the fort's curtain wall done in Photoshop.

adjusted by Crazy Bumps according to intensity sharpen, detail, shade, and highlight, and were then imported into Maya in order to further adjust the respective surfaces with the UV texture editor in Maya. Finally, the normal maps were placed along with the displacement maps onto a Blinn bump map for particular buildings. Most texture images were provided by a website referenced as Cgtextures, which has abundant and wide resources for textures that range from ancient to modern. The textures for the log palisades, the roofs and the wooden walls of the two storehouses were from Cgtexture, and the limestone textures were from the actual remnants of Fort Frontenac.

Following these methods of texturing buildings, a dynamic moving sky was created. The sky image was distorted using polar coordinators in Photoshop and the hemisphere modeling was mapped with the image onto the UV texture editor under spherical mapping. Moreover, geographic landscapes were created in Maya by means of tracing curves over the outline of the plans for 1685 [8], which were provided by the City of Kingston. The outline became a planar surface, and that surface was converted into a polygon surface

with numerous quarter geometries. The geometric maps were shot by UV Snapshot included in the UV texture editor in Maya and were imported into Photoshop to create color geographic topography. Furthermore, the sea was created by means of using Ocean Shader and Ocean, and minor corrections were required until the color was very similar to the color of the sea around Kingston that was dully emerald or bluish in color.

Three lights were also set up: Key Light, Fill Light, and Back Light. The Key Light acted like sunlight set as a directional light, turned towards the north, and its color was slightly bright yellowish. The Fill Light acted as a secondary light set as a spot light facing southwestward, and its color was slightly bluish. The Back Light was the third light set as an additional spot light in a southern direction, and its color was dimly warm orange. Originally, the fort's gate was turned northeast so that the entrance was in shadow in the northeastern direction. The three lights were essential materials used to strengthen an aesthetic sense of natural imagery. Lastly, in order to make shadows look realistic, AO (ambient occlusion) was used to help soften and deepen shadows and to refine a clearly visible separation between objects in a totally white scene. This technique is used to create a more realistic AO rendering (Figs. 5-8).

(2) Rendering Sequences to Create Videos and Interactive Design: Regarding the camera animation, rendering was done for the PNG sequences featuring an overview of the fort and it's inside views for the series of all of the construction dates for 1675, 1680, 1685, and 1688, as well as providing ambient occlusion renderings for those scenes in video clips. The 1673 version was not included because the inside view was too narrow to create a video. A "Two Node" camera was set as the camera body with an aim constraint. Different circular curves were created to become a motion path attached to each camera in order to make the cameras move very smoothly. Nine hundred frames were required for an overview of the

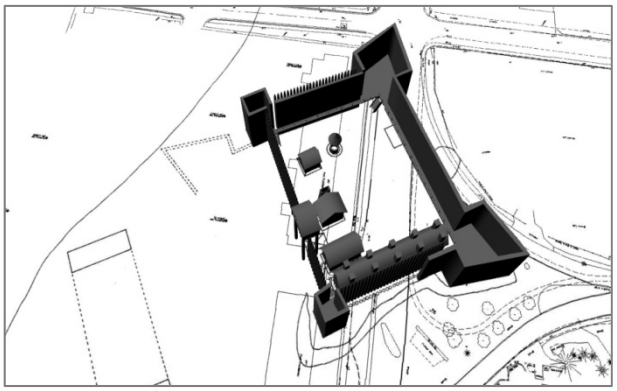

Fig. 5 The foundation model of the 1680 fortress.

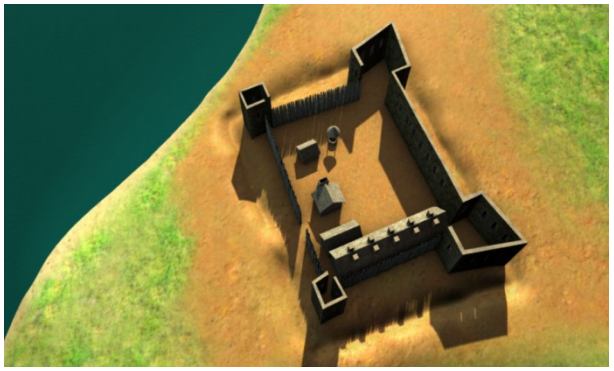

Fig. 6 The completed model of the 1680 fortress.

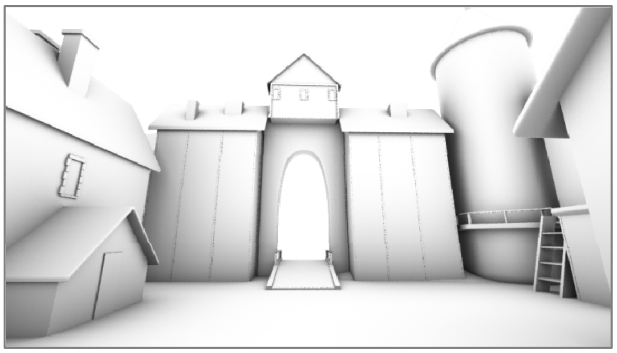

Fig. 7 The restoration of the entrance of 1688 fortress in AO.

Fig. 8 The completed restoration of the entrance of 1688 fortress in 3D computer graphics.

exterior of the 1688 fort and ambient occlusion renderings for the fort in sequence. It took an average of six to nine hours to get this smooth for the videos.

Both of the completed sequences were imported into Adobe After Effects software and then placed as AO sequences under the "multiple" color sequences setting in order to be semitransparent, making the sceneries appear more realistic, and then rendered for videos. The preferable time length for the videos was twenty-four seconds for an overview of the exterior. These setups were needed to make viewers visually comfortable according to the motion and timing.

Two videos were set as a chronological series showing the two kinds of entire exteriors of the forts. The images for each were simply taken from Maya, which was an easy way to ensure that each image was ordered chronologically and the corresponding chronological date texts were aesthetically put on each of the images in After Effects. For the aspect of interactive design, only thirty-six frames were required to render an overview of the exterior and interior of the forts, including ambient occlusion renderings for both locations. It took thirty minutes to set all of the frames and install the historical sequences for 1673, 1675, 1680, 1685, and 1688, respectively.

3.2 Creating Interactive Imagery in Flash

Flash CC is reliable software designed to play a major role in interactivity. An SWF format generated from Flash was designed for the interactive application of this project and was equipped to become integrated with the website. From a technical view, the interactive animation was set up to play at arate of only thirty-six frames. The coding was typed and fixed on the action scripts in order to fit the interactive scenery (Fig. 8), and the names and descriptions of each of the buildings were placed in panels. These panels were placed around each building using transparent black color with high opacity on the basis of its visual effect. Once the SWFs were published, the interactive system enabled users to hover over a certain building with a mouse where the panels, including its name and description popped out (Fig. 9). This idea can be a useful educational tool to let users learn about the fort's historical importance and to acquire new knowledge, as well as assisting in the development of educational and study materials.

3.3 Designing the Website

Using a website as a hub can encourage most of the public to learn about the archaeological and historical results of the visual transformation of the fort's renovation process. Using the website, people worldwide can visualize the images of the fort in 3D. In terms of layout design, the color of the top bar was a slight crimson, and the main background was slightly yellowish beige or grey with high opacity under the old map. The reason for the color choices were that the outline and background of the old fort's map plan had colors in common with the roof and wall of the National Defence College that were built on the front of the fort's remnants. The site reanimates time reenactments of these French settlements in Canada (Fig. 10).

The design of the webpage was implanted with historical descriptions, video clips, and interactive sceneries. Those people interested in history and archaeology can vicariously enjoy spending more time learning the information about altering the features of the edifices in chronological order, and this observation can promote new knowledge during their visit.

Fig. 9 The interactive scenery of the 1680 interior fortress.

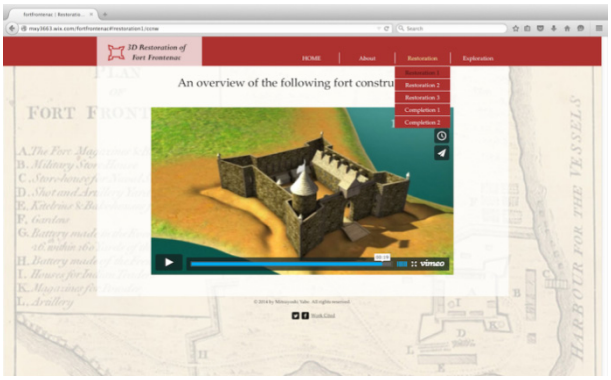

Fig. 10 A 3D video of the restoration of Fort Frontenac in the website.

3.4 Effective Use of an iPad and iPhone for 3D Augmented Reality

The Kingston Archaeological Center had closed, but the outcome of the research about Fort Frontenac will have the potential to be able to contribute to the commercial development of Kingston tourism if it is exhibited as something of interest at the city hall or an information center. An old map of the fort, an iPad and an iPhone could be set up at specific locations as a favorite way of entertaining citizens and tourists (Figs. 11 and 12).

The interactive applications took advantage of a virtually dynamic emergence of Fort Frontenac done in Maya modeling that were then integrated with the use of an iPad or an iPhone by using Metaio software, where a completed 3D model was inventively positioned on a scenario editing area as well as the images of the old map. During the transfer from a computer, Metaio created a specific barcode called "QR code" to specify the paths needed to configure the tracking, and a QR code reader application called "Junaio" scanned the QR codes into an iPad or an iPhone. Generating 3D augmented reality with an iPad and an iPhone is one of the most cutting-edge technologies available today. Another method to accomplish this, was to simply combine an immersive photo of the remnants of Fort Frontenac with an immersive copy of an old, historical plan of the fort created in 1685, which can show the conflicts between the latest technology and the conventional prints. By slowly lifting the iPad to fit the outlines of the remnants of the photo with a copy of the historical plan, a virtual 3D feature of the fort buildings completed in 1688 suddenly emerged from them.

This energetic appearance has fantastic messages for users that are worth thinking about working within the technical conflicts in favor of pleasantly thrilling the viewer. It draws users into moving around the map and photo in different perspectives as well as in a 360-degree view. These activities also draw users into having wonderful experience interacting with the 17th century.

3.5 Critical Analysis and Troubleshooting

The ideal plan was to create the system for an iPad

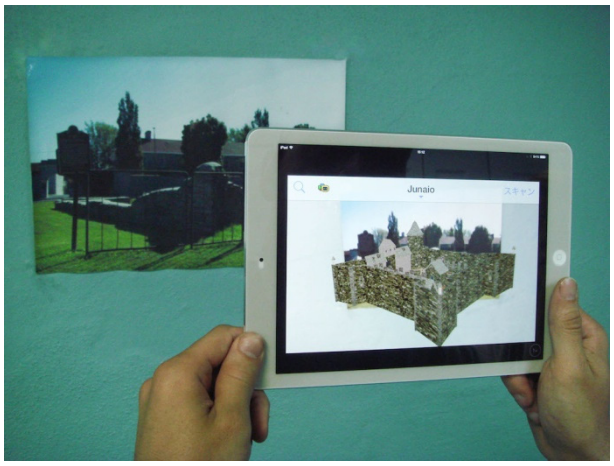

Fig. 11 The scenery of using an iPad for 3D Augmented Reality.

Fig. 12 The scenery of using an iPad for 3D Augmented Reality.

or an iPhone where users can operate and click on the chronological buttons: 1673, 1675, 1680, 1685 and 1688, in favor of making each of the buildings pop out from the same photo and copy. The system's dynamic appearance would make users excited to interact with it. The system should have included the investigative consequences of the indispensable, altered features of the fort restoration in chronological order. Unfortunately, many 3D augmented software, such as Metaio, were unable to perform the operation for the numerous amount of buttons. In addition, some of the building textures were lost while the fort was loading and popping up. The original texture images had to be updated in order to reduce the texture sizes and to their formats in Maya. Many had been replaced with other new textures in case the size reduction was insufficient. It was required to resolve the issues with the formats and sizes in order to feature the textures in an appropriate condition for the fort. After the solutions were completed, the 3D fort became improved better and became more attractive to the website users.

In addition, the requirement of the user to lift their arms and hands became frustrating because the user's arms got tired and were shaking a lot over time, although it was necessary to avoid continuous shaking in order to bring the 3D model into true focus.

Nine hundred frames were crucially required to produce a 36-second video for the outside overviews and six hundred frames were required to produce a 24-second video for the inside overviews. Rendering nine hundred frames greatly impacted the researcher's lifestyle on a daily basis, in that it took one day to complete one video. On the other hand, creating the interactive sceneries for the outside and inside of the forts in Flash CC took only 30 minutes to render all twenty-four frames necessary to build a 360-degree interaction in Flash. At that rate, more than 10 interactions could be created on a day.

However, designing a related website was influenced by the formats of the video files and the interactive sceneries for each page. User-centered design determined the best method to incorporate the videos. Consequently, most videos were removed due to their memory-intensive usage and the time management required. Only the videos for the completed exterior fort in 1688 were uploaded for the webpage. The website featured nine interactive sceneries: the exteriors for 1673, 1675, 1680, 1685 and 1688, as well as their interiors respectively, except for 1673. The appearance of the website and 3D augmented reality created with an iPad were innovative and comfortable for users to enhance their knowledge in an effective way, while in comparison, simply watching videos was not innovative design and seemed banal. To sum up, the use of this design could assert that interactive applications are attractive to users and usefully economize the time spent creating them, but featuring videos is relatively conventional and expends considerable effort and time. Furthermore, the ability to watch the videos and interactive sceneries depends on the capacity of the user's Internet connection.

4. Conclusions

The subject of this paper was the historic virtual rendering of Fort Frontenac in 3D technology, and discussed how this virtual rendering could educationally and experientially prevail in the demonstration of archaeological research by using the development of the newest technology, and assessed the usability of this format through the creation of a website to be accessed on PCs and compact devices like iPads. In accordance with the research process and ensuing issues, a means of 3D dimension alization has been found and its advantages have been discussed.

On the PC website, proving this collaborative and observable evidence needed the inclusion of videos and interactive sceneries of the front view and a 360-degree view of exterior and interior of the fortress. The information presented through the videos and

interactive sceneries, followed the gradually widening of the walls, whereas the height of the walls did not change. The number of garrisons living inside the fort also affected the direct relationship between the width and the height of the fort's walls. In order to produce the videos and interactive sceneries, modeling the buildings and the related environment presented a lot of challenges and many difficulties because there was very little information available about 17th century Fort Frontenac. Further research and information was needed to clarify that Fort Frontenac compared with other forts that were relatively similar to the target fort according to their various sizes, such as the height, length, and width of the buildings, as well as the textures of the buildings and the environment surrounding them.

In accordance with the development of 3D augmented reality, the Metaio software was critical to the appearance of the 3D fort, button operation, and physical ease of use. 3D Augmented Reality software is still developing and will be able to produce versatile button operation to create and support the use of chronological buttons. It will reduce the burden which users' arms are subjected to by gravity while lifting the devices with their hands. By changing the consumer's understanding to an archaeological viewpoint, the field continues to evolve step-by-step. 3D techniques and web design have gradually supported this evolution, even though the technology is still developing in areas such as comfort and convenience for modeling, importing colors and sounds, lighting, shading, setting items into motion in 3D, visually communicating 3D augmented reality on a screen, and using buttons with an iPad, an iPhone, and a mouse to interact with a website. The project can state facts backing up information regarding historical sites that have been abolished, are in bad condition, or that are in repair, which can then be resuscitated and examined through the use of the latest technology, including videos and interactive sceneries such as those in this research that demonstrated and proved the different sizes of the fort restoration as they occurred in chronological order. The requirements of the general public were kept in mind in order to foster research that could help to develop an area's municipal economy and commercial tourism.

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