Resolving The Conflict between High Visual Quality and High Performance in Virtual Reality Applications

Keys to Rome project as case study

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***Abstract*—This paper aims to show how the 3D unit at the Center for Documentation of Cultural and Natural Heritage (CULTNAT) tackled the conflict between High visual quality and high performance in Virtual reality application by implementing a set of techniques in order to reach the highest performance and visual quality, Keys to Rome project as an example of this practice.The challenge was on two levels. The first level was optimizing the scanned museum objects making it look realistic and in the same time small in data size, level two was the 3D scene/location were the user will navigate.**

***Index Terms*—virtual reality, re-topology, normal map, keys to Rome, Vmust, photogrammetry, Ambient Occlusion map.**

I. Introduction

Keys to Rome is an international exhibition on Roman culture that was launched simultaneously in Rome, Sarajevo, Amsterdam and Alexandria on September 23, 2014.

The exhibition focused on the use of immersive virtual reality technology to present and connect these regional cultures within the Roman Empire, highlighting their diversity and commonality over centuries of Roman rule.

Combining real artifacts digitally restored 3D objects and virtual environments, visitors can travel back in time to search for lost objects and discover more about the lives of their owners through a game like application.

The exhibition also includes the Digital Museum Expo: a showcase of interactive and immersive technologies developed for use in museums.

Keys to Rome is organized by V-MusT, the Virtual Museum Transnational Network, and curated by archaeologists, art historians, architects, computer scientists and communication experts. Each venue features an immersive 3D game called the Admotum that allows visitors to travel back in time and explore virtual environments and objects.

II. Challenges/ Problem statement

The main challenge was how to meet the high demands of virtual application with reference to performance while achieving high visual quality. There is an inverse relation between high visual quality and its cost on performance, date size and hard ware. The challenge was to deliver the highest visual quality possible, with smooth fast performance and low data size.

In this section we will explicates the gradation of challenges and how they were handled.

A. Digitizing the museum objects

The First step was how to transform the Museum objects into zeros and ones in order to be able to process them. This was done with photogrammetric processing of digital images to generate 3D spatial data. Photogrammetry is the science of obtaining reliable information about the properties of surfaces and objects without physical contact with the objects, and of measuring and interpreting this information. During the Keys to Rome project a total of (18) museum objects were scanned using Agisoft PhotoScan software. Average of (90) photos were taken for each object distributed between 7 to 9 degrees around the object covering all angels and directions as shown in Fig 1. Photoscan technology is an image based 3D modeling solution to produce 3D content from still images.

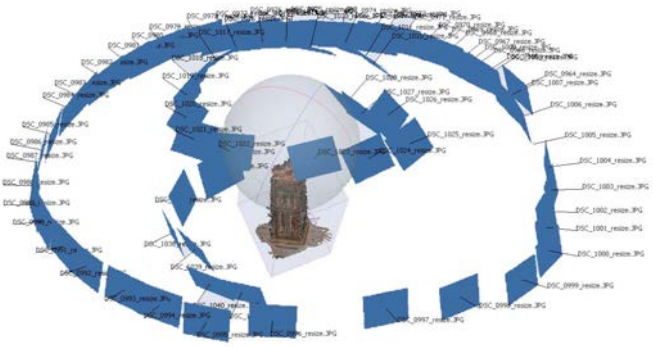

Fig. 1. Camera distribution for one museum object

Fig. 2 show a sample for a scanned museum object “round seal cross” using Agisoft photoscan the result is a 500000 high density polygon count.

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Fig. 2. Scanned round seal cross from museum objects.

B. Optimizing the museum objects and scene 3D models for Virtual reality applications.

The results were a very high poly count objects even with the simplest object forms.

This meant huge data size and poor performance and the need of the highest cost hardware in order to reach acceptable performance. This was simply unacceptable.

The first answer that comes to mind was using simplification modifiers found in any 3D modeling program to bring down the polygon count. This was not the answer to our problem because the efficiency of this method was limited. The percentage of decrease within the polygon count once exceeded a certain percentage the model deforms, producing Irreparable or the least multiple errors, fixing that would have been total waste of time. Figure 3 show the deformation caused when trying to exceed 90% decrease in poly count using optimize modifier in 3D max, the deformed model polygon count is 9000.

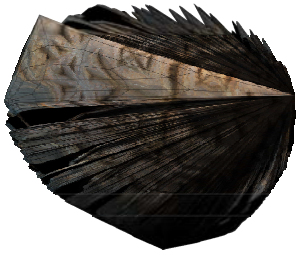

Fig. 3. Modified round seal cross using optimize modifier.

Another solution was needed. It was the use of a combination of techniques on two levels the 3D mesh and the 2D textures level.

III. Problem Solving Methodology

Human interference was needed to decide the polygon shape and count needed, the role of 3D artist comes in hand now through the use of re-topology technique. “Topology is the term used for the pattern of polygons that make up a mesh. People talk about ‘good topology’ for when a mesh is well made for a particular task such as animation, or ‘bad topology’ for a mesh that may result in problems in certain situations” http://docs.pixologic.com/user-guide/3d-modeling/topology/.

The 3D artist will be the judge on which surface to be covered by one polygon and which areas that needs several polygons using the appropriate tool in any 3D modeling program (zbrush, 3Dmax, topogun), putting in mind the use of normal maps to complement the details needed to deliver visually accurate model plus normal reaction to light. The mix between the 3D low but smart poly and Normal maps generated from the high poly model plus AO maps all as well as the main texture map help achieve real life scene.

Through the process of re-topology technique and the several enhancements done on the models output the 3D artist learning curve was exponentially increasing achieving a (1.0%) of the original model poly count in many cases, that is a 99.0% decrease, depending on the complexity of the figure this could be done within one to two days of work. Figure 4 shows four different states of the same museum object “Head of Serapis” on the left side (A) the high poly mesh 805180 polygon count and (C) the same object in the textured state on the left side (B) the low poly mesh 8870 polygon count and (D) the textured model of the same low poly object.

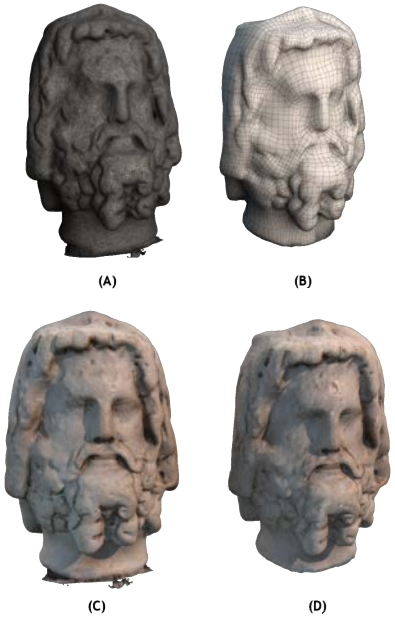

Fig. 4. Scanned and optimized head of Serapis

Figure 5 shows four different states of the same museum object “round seal cross” on the left side (A) the high poly mesh 500000 polygon count and (C) the same object in the textured state on the left side (B) the low poly mesh 418 polygon count and (D) the textured model of the same low poly object.

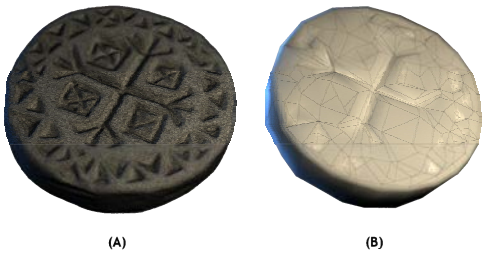

Fig. 5. Scanned (left) and optimized (right) round seal cross

Another benefit of re-topology was simplifying the proses of unwrap uvw in 3D max, now you are dealing with a simplified mesh thus the 2D projection of this form will be easily handled and easily assigned to its respective texture. “The Unwrap UVW modifier lets you assign mapping (texture) coordinates to objects and sub-object selections, and to edit those coordinates by hand as well as with a variety of tools. You can also use it to unwrap and edit existing UVW coordinates on an object. You can adjust mapping to fit on Mesh, Patch, Polygon, HSDS, and NURBS models using any combination of manual and several different procedural methods.” http://knowledge.autodesk.com/support/3ds-max/learn-explore/caas/CloudHelp/cloudhelp/2015/ENU/3DSMax/files/GUID-EA10E59F-DE7F-497E-B399-6CF213A02C8D-htm.html

Figure 6 show a screen shot of a unwrap uvw in 3D max of the high poly mesh, it is clear the complexity of the column projection making it impossible for the 3D artist to assign the textures coordinates to their corresponding objects or sub objects. Figure 7 show a screen shot of the unwrap uvw in 3D max of the simplified column using re-topology, it is clear the difference in complexity between the two states of the same column when comparing Fig. 6 to Fig. 7.

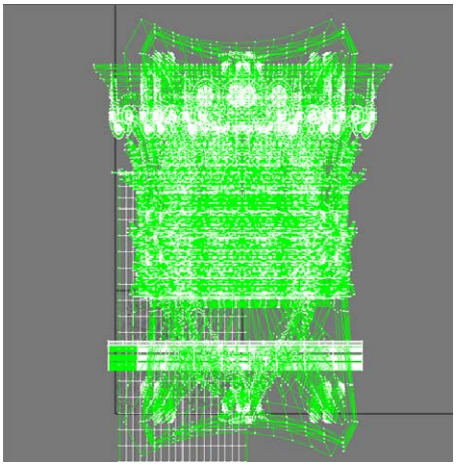

Fig. 6. Complex column projection

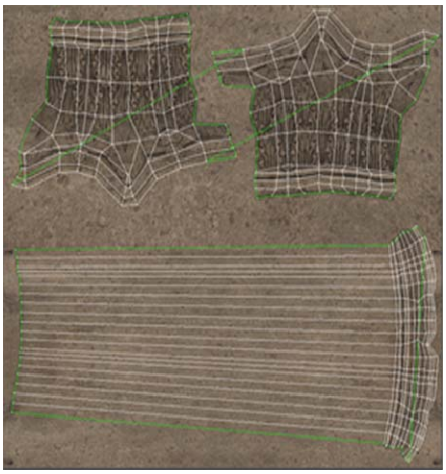

Fig. 7. Simple column projection

The Next step was generating normal maps for all the sophisticated elements that were optimized using re-topology like columns crowns or the scanned museum objects to complete the process of visual optimization and complement the details needed to fake the shape details missing and enhance model reaction to light, normal maps were generated from the high poly models as well as the diffuse and Ambient occlusion maps. Xnormal software was used to do the job of generating the normal maps and marmoset software to visualize and experiment the model reaction to light in different light moods as well as it’s all over smoothness of performance. Figure 8 is an example of the three main maps generated for some of the museum objects and architecture elements of the project.

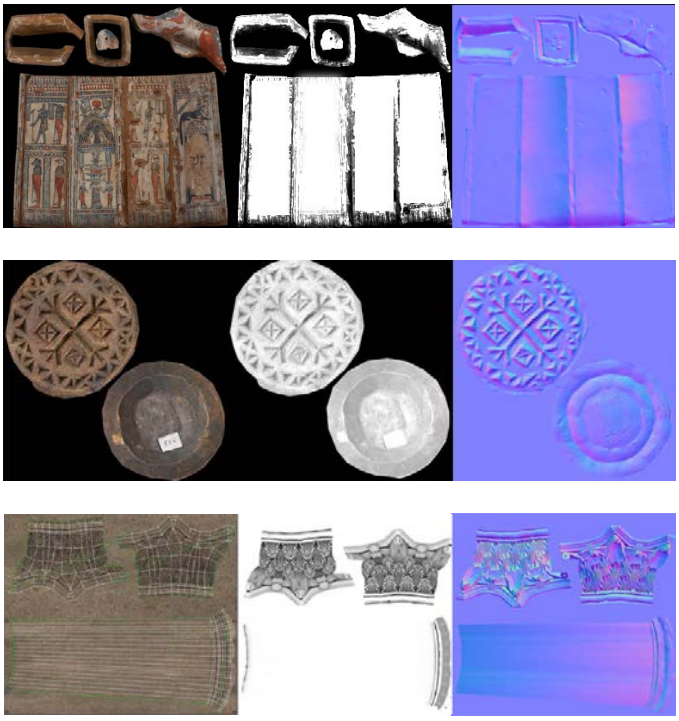

Fig. 8. From right to left normal map, Ambient occlusion and diffuse map

IV. Conclusion

Maintaining high visual quality while achieving high performance and smoothness help enrich the user experience with the application resulting in higher understanding and enjoyment of the purpose of the application (in our case 60 rendered fps were easily met). One of the observations at keys to Rome exhibition was that visitors of the exhibition spent more time on the virtual reality scenes with better visual quality in that case it was the Serapeum temple done at the 3D unit of CultNat. A version of the immersive 3D game (the Admotum) was uploaded to keys.cultnat.org.

The Figures that follows highlight the main conclusion of the paper. Figure 9 show the difference between three states of the same column the first one (A) consist of 426 polygons is done through re-topology technique the one in the middle (B) 16500 polygons is an optimized mesh using optimize mesh modifier the last one on (C) 40000 polygons is the original high poly mesh. Figure 10 show the same columns heads of fig. 9 but in the texture state.

Fig. 9. Comparison between three states of the same column

Fig. 10. column heads in three states

Figure 11 show the same museum object" Naos representing the God Horus" before and after optimization using re-topology, (B) before optimization the poly count was 26387 polygons (A) after optimization it became 1003 polygons.

Fig. 11. Comparison between the low poly and high poly of Naos representing the God Horus model

Figure 12 show another example of a museum object " Statue of Horus the Child" before and after optimization using re-topology, (A) before optimization the poly count was 999800 polygons (B) after optimization it became 5300 polygons

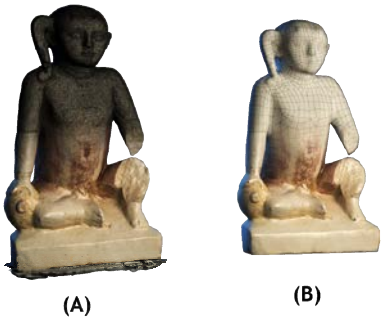

Fig. 12. Comparison between the low poly and high poly of Statue of Horus the child

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